THE OHIO JOURNAL OF SCIENCE

VOL. XLIII SEPTEMBER, 1943 No. 5

VARVES IN SANDUSKY BAY SEDIMENT

IRA T. WILSON
Heidelberg College, Tiffin, Ohio

While determining the quantity and distribution of the sediment in Sandusky Bay near the western end of Lake Erie for the Division of Conservation of Ohio, the writer found the deposits to be varved. Since several nearly complete cores of sediment were secured, an estimation of the total number of varves has been possible. Estimates of three cores have been made, two in the Bay proper and one at the edge of the Bay. This last core penetrated 10 feet of deposit that lies above the level of the Bay floor that is not represented in the other two borings. Since it represents as complete a profile as is likely to be found of the lacustrine deposits of the glacial waters that covered northwestern Ohio for a considerable part of post-glacial time, it was thought that the varve count might be of interest to glaciologists.

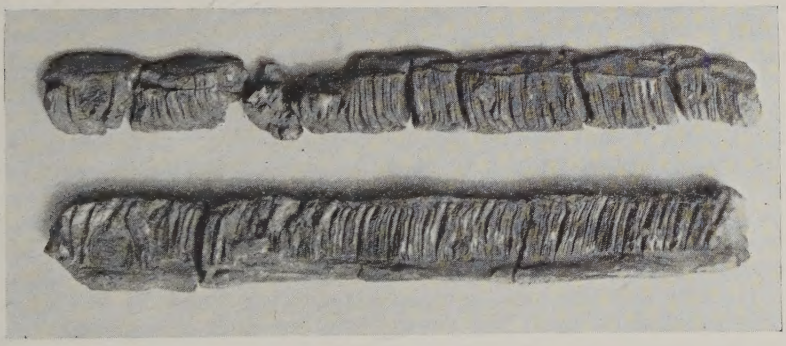


FIG. 1. A piece of core from a boring near the center of Sandusky Bay torn open thus exposing the varved structure of the deposit. After being torn open the core was allowed to dry which caused enough shrinkage to accentuate the gaps between the layers. The visible layers are only one-half of those actually present; they are the thicker winter deposit. The very thin quartz layers, between those that are visible, that make up the summer deposit do not show in the photograph.

The Bay lies inside the shorelines of the glacial lake that existed in front of the Huron-Erie lobe of the Wisconsin ice sheet. As inferred from Taylor's account (Leverett and Taylor, 1915)[1] glacial waters covered the region from the late Maumee stage, through the Arkona, Whittlesey, Wayne, Warren and Elkton stages. After the Elkton stage the melt water of the upper lake (Algonquin) found drainage eastward (Kirkfield outlet) and lowered the lake level in the Erie

[1]Leverett, Frank, and Taylor, Frank B., 1915. The Pleistocene of Indiana and Michigan and the history of the Great Lakes. United States Geological Survey. Monograph 53: 316–518.

basin below that of the Bay region, thus ending deposition there. The present Bay is the widened mouth of the Sandusky River which cut its way through the lacustrine deposits of this series of lakes after the Elkton stage. The glacier was retreating from Sandusky Bay to a point near the Niagara gorge during the period of deposition of the sediment referred to here—a distance of approximately 250 miles.

The cores of sediment were secured by driving the sampler (¾-inch tube) into the sediment approximately one foot at a time in soft sediment and as little as two inches in hard sediment. An attempt was always made to get a sample of the same length as the distance the sampler was driven into the sediment. This procedure avoided compaction of the sediment. The sampling was carried on inside a casing that was always driven to the level of the bottom of the last sample and washed clean before a new sample was taken. This method entailed the loss of about two inches of core between each sample. Cores were torn open lengthwise to reveal the varved structure. Examination of Figure 1 reveals the varved structure of a typical sample.

The technique of estimating the total number of varves consisted first, in dividing the depth of the boring into increments and counting accurately the varves of the available sediment of each increment, and second, determining the average number of varves per inch (in the available sediment) and multiplying this by the number of inches penetrated in securing the samples included in the increment. This method gives an estimate that includes the portions of sediment lost between samples. Finally, the estimates of all the increments were added together to secure the total number of varves in the core. In choosing the increments care was taken to include as uniform thicknesses of varves as was possible, thus keeping the deviation of any of the varves from the average of its increment at a minimum.

Both the winter and summer layers of the varves in the deposits reported here are very distinct, one of them being thin, white and composed almost entirely of fine quartz crystals, whereas, the other is thicker, dark and composed mostly of clay, some carbonates and a slight amount of organic matter. The particles of the white quartz layer of the varve are so poorly cemented that the core easily breaks apart along it, but those of the dark stratum are well cemented together. Frequently the dark stratum of a varve shows eight or ten subdivisions that may represent disturbances of settling caused by individual storms.

The sizes of the particles that make up the varved deposit vary from 50% at some levels to 60% at others that are less than 2 microns in diameter. Maximum sizes (found only at the lower levels) vary from 35 to 80 microns.

Table I shows (for the most complete core—it includes 10 feet of sediment above the present Bay level) the depths limiting each increment, the average number of varves per inch, the total number of varves in each increment, and the total number of varves for all the increments, i. e., in the complete core. The total depth of sediment in this case is 37′ 7″. The sediment of this boring lies on bed rock. It can not be stated definitely that this core includes all of the deposit of the glacial lake under consideration since some may have been lost by erosion or by removal by readvancing ice. Erosion has probably been slight due to the extreme flatness of the region. The varve estimates made in the three cores gave comparable results.

An examination of the column in the table labelled "Av. per inch" shows that the varves vary in thickness somewhat at different levels. Twelve and one-half varves is the minimum number per inch and 38 the maximum. Although there are minor fluctuations from increment to increment in the number of varves, there is in general a decrease in the number per inch from the lower to the higher levels of the deposit, i.e., the varves get thicker the nearer the surface is approached.

This indicates a greater annual deposition in the higher levels. The differences in thickness of varves are due almost entirely to differences in the dark layer. Dr. George M. Stanley (personal communication) suggests that "the increasing thickness of varves towards the top of the section is largely a result of the shallowing lake and nearer shoreline, since this is probably the principal source of sediment."

TABLE I

RECORD OF THE ESTIMATES BY INCREMENTS (SELECTED BECAUSE OF THE UNIFORMITY OF THICKNESS OF THE LAYERS WITHIN IT) OF THE VARVES IN A BORING A FEW FEET BEYOND THE SOUTHERN EDGE OF SANDUSKY BAY ON LAKE ERIE. ESTIMATES ARE NECESSARY BECAUSE A FEW INCHES OF THE CORE BETWEEN EACH SAMPLE TAKEN WERE LOST. THEY WERE MADE BY DETERMINING THE AVERAGE NUMBER OF VARVES IN THE AVAILABLE SEDIMENT (USUALLY ABOUT 75%) OF EACH INCREMENT AND MULTIPLYING THIS NUMBER BY THE TOTAL NUMBER OF INCHES IN THE INCREMENT

Depth of Increments	Average Number of Varves per Inch	Number of Varves in Increments	Depth of Increments	Average Number of Varves per Inch	Number of Varves in Increments
0– 1′5″	12.5	212.5	18′–19′3″	31	465
1′5″–2′2″	16	144	19′3″–20′7″	33	528
2′2″–2′11″	21	189	20′7″–21′11″	36	540
2′11″–4′4″	18	306	21′11″–23′5″	32	576
4′4″–4′10″	17	102	23′5″–24′	29	203
4′10″–5′8″	16.5	165	24′–25′	29	348
5′8″–6′4″	22	176	25′–25′6″	28.6	171.6
6′4″–6′11″	17	119	25′6″–26′6″	30	360
6′11″–7′5″	19.5	117	26′6″–27′	33	198
7′5″–8′	16.5	115.5	27′–28′	38	494
8′–9′	19	228	28′1″–28′6″	34	170
9′–9′10″	23	230	28′6″–29′7″	33.5	435.5
9′10″–10′8″	21.5	215	29′7″–30′	36	180
10′8″–11′8″	20	240	30′–31′1″	34	442
11′8″–12′8″	27.5	330	31′1″–32′7″	28	504
12′8″–13′8″	27	314	32′7″–34′1″	28.5	513
13′8″–14′8″	32	384	34′1″–34′10″	29.5	265.5
14′8″–15′8″	32.5	390	34′10″–35′8″	29	290
15′8″–16′8″	28.6	323.2	35′8″–37′2″	30	540
16′8″–18′	34	544	37′2″–37′7″	31	155

Grand Total of Varves, 12,223

The total number of varves in the core, namely, 12,223, certainly represents the minimum number of years that the Sandusky Bay region was covered by cold glacial waters. Since the Erie lobe of the glacier receded approximately 250 miles during this time it must have receded at an average rate of 108 feet per year.

The writer is indebted to the Department of Conservation of Ohio for financial support for the field work, to Dr. T. H. Langlois, of the Franz Theodore Stone Biological Laboratory for arranging for the work and for many suggestions, to Dr. George M. Stanley, of the University of Michigan, for suggestions and criticism, to Robert Heaver and Robert Wilson for helping do the field work, and to Donald Wohlschlag and Albin Jankowitz for assisting in counting the varves and determining the proportions of various particle sizes.

STUDIES IN THE BIOLOGY OF THE LEECH.[1] VI.

The Anatomical Basis for Certain Leech Behavior

JOHN A. MILLER
Department of Zoology and Entomology,
The Ohio State University, Columbus, Ohio

The behavior of an animal is the result of stimuli acting upon a particular arrangement of anatomical structures. In the leech a specific neuromuscular pattern is present. Motor neurons of this mechanism can be stimulated directly by direct current of low voltage. Miller (1934). The responses of the leech in an electrical field constitute the experimental basis upon which the probable arrangement of motor neurons enervating body wall muscles has been postulated. Miller (1936). The polarity of motor neurons is determined by the application of the "law of polar stimulation." Lillie (1923). The same technique has been successfully applied by Shensa and Barrows (1932) in their study of galvanotropic responses in the earthworm. The position and extent of the motor neurons in both the leech and the earthworm have been suggested by the resulting behavior of the organism. In every instance where the behavior of the organism involved only a few segments, it was apparent that motor neurons within the cord extended through several ganglia. In the present paper I propose certain anatomical features in support of the experimental evidence previously reported.

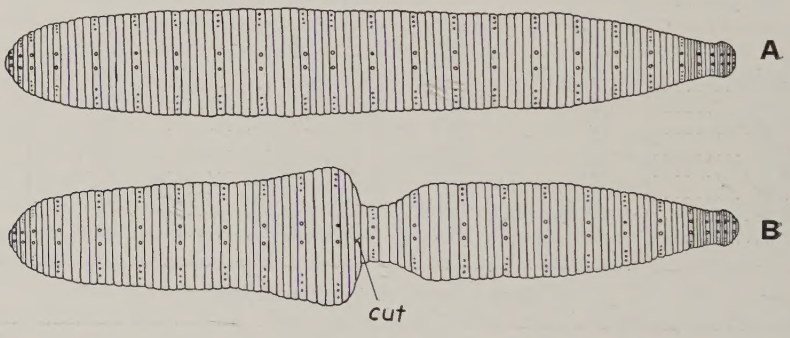


Fig. 1. A. The normal shape of the leech. B. The change in body form following nerve cord transection.

In a preceding paper of this series, Miller (1942), there was presented an account of the deviations in body form following nerve cord transection. Fig. 1. The specific reaction to which I was to refer is one occurring in the mid-body region following the transection of the ventral nerve cord. The operated leech showed in the region of the severed cord a constriction extending anteriorly, and an enlargement extending posteriorly. In the mid-body region a typical segment consists of five annuli. The affected area extended from three to five annuli anterior to the cut and from four to six annuli posterior to the cut. The area affected depended upon the relation of the cut to the segmental ganglia.

In the segment anterior to the cut, there was a loss of tone in the longitudinal muscles. Posterior to the cut there was a corresponding loss of tone in the circular

[1] *Haemopis marmoratis* (Say).

muscles. The minimum area affected embraces no less than two complete segments. From these observations it seemed reasonable to imply that motor neurons extended for short distances in the cord. According to Smallwood (1930) inter-

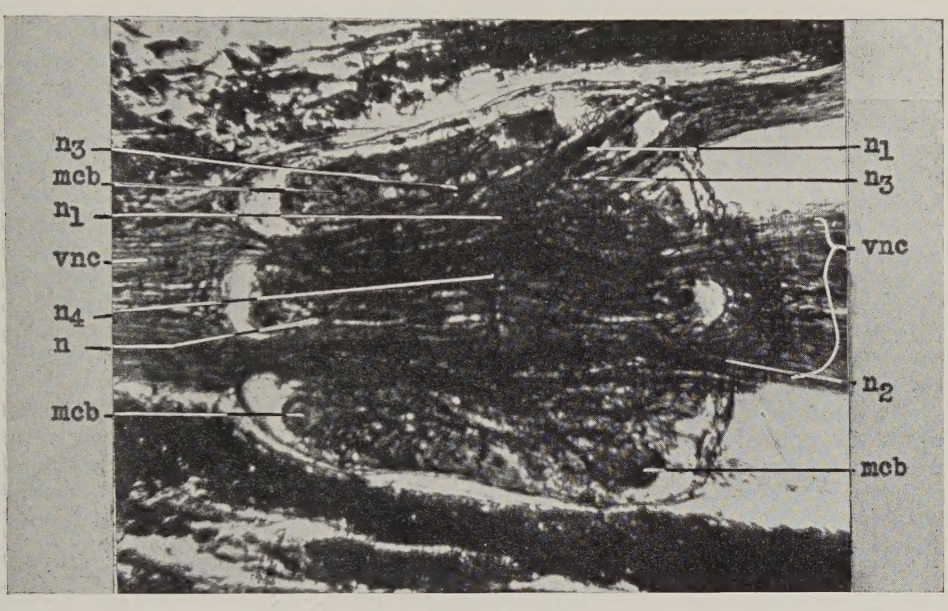


FIG. 2. Photomicrograph. A frontal section through a leech ganglion.

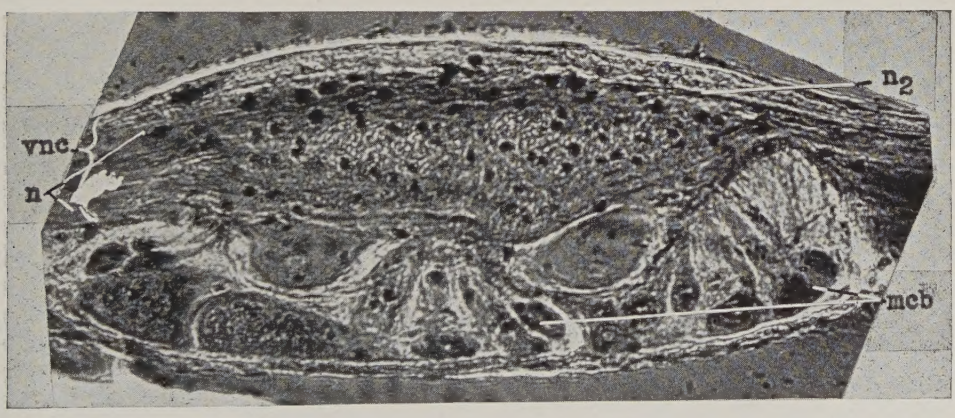


FIG. 3. Photomicrograph. A longitudinal section through a leech ganglion. (v. n. c.) Ventral nerve cord. (n.) Interganglionic processes. (n_1) Interganglionic processes entering a lateral nerve. (n_2) Interganglionic processes continuing through the ganglion. (n_3) Motor axons entering immediate lateral nerve. (n_4) Motor axons extending into the ventral nerve cord. (m. c. b.) Motor cell bodies.

ganglionic neurons in the earthworm are small in size and few in numbers. Smallwood further states that these interganglionic nerve cells play but a small part in transmitting impulses from ganglion to ganglion. It is his contention that interganglionic correlation is the function of the giant fibers. Ogawa (1939), also

working with the earthworm, described numerous interganglionic nerve cells. Of the three types described, one which he calls "the gross cell" and which was previously mentioned by both Retzius and Krawany, is motor. This type of cell is described as passing over two or three adjacent ganglia. These are unipolar cells, the axon of which gives off numerous collaterals during its course.

In leech preparations, Figs. 2 and 3, using a special technique developed by the author, neurons similar to those described by Ogawa can be traced. In both frontal and lateral views interganglionic processes are visible. Certain of these processes enter the lateral nerves (n_1); others continue through the ganglion to adjacent segments (n_2). In passing through a ganglion, these long fibers occupy a position dorsal to the mass of nerve cell bodies. Fig. 3. In each ganglion large motor cell bodies are observed in well defined areas. Figs. 2 and 3. Several distinct types can be differentiated, among which are those whose axons enter the immediate lateral nerves (n_3), while others send their protoplasmic extensions into the nerve cord (n_4). This anatomical evidence substantiates the previous conclusions derived from experimental evidence, namely, that motor neurons extend short distances in the cord. It further offers an anatomical basis for understanding the segmental behavior following nerve cord transection.

The position of the nervous elements in the central system of the leech have, up to the present time, been determined almost entirely upon inferences drawn from experimental evidence. This is the first of a series of papers based on the neuro-anatomy of the leech and devoted to an analysis of the action systems, whereby the functional relationship of this mechanism can be applied to an understanding of the behavior of the organism.

LITERATURE CITED

Lillie, R. S. 1923. Protoplasmic Action and Nervous Action. Univ. of Chicago Press, pp. 1–417.

Miller, John A. 1934. Studies in the Biology of the Leech. No. II. The Ohio Jour. Sci., 34: 57–61.

1936. Studies in the Biology of the Leech. No. IV. The Ohio Jour. Sci., 34: 343–348.

1942. Studies in the Biology of the Leech. No. V. The Ohio Jour. Sci., 42: 45–52.

Ogawa, Fumiyo. 1939. The Nervous System of Earthworm (*Pheretima communissima*) in Different Ages. Sci. Reports, Tohuku Imperial Univ., 4th. series, Biol., 13: 295–488.

Shensa, L. S. and **Barrows, W. M.** 1932. The Subepidermal Nerve Plexus and Galvanotropism of the Earthworm, *Lumbrious terrestris* Linn. The Ohio Jour. Sci., 32: 507–512.

Smallwood, W. M. 1930. The Nervous Structure of the Annelid Ganglion. Jour. Comp. Neur., 51: 277–392.

Cytology

A highly condensed description of the equipment and procedures used in the study of both animal and plant chromosomes. Consequently the user of the book will find himself repeatedly forced to seek out other sources of information. For example, the technique of centrifuging is disposed of in two lines on page 69 by citing three publications. There are 25 pages of bibliography. The book will therefore be very useful as a subject guide to the literature. Two matters of conjecture are stated in ways that may give the incorrect impression that they are established facts: on page 18, chromosomes ". . . are amongst the largest molecules . . .;" and on page 59, in salivary gland chromosomes ". . . each gene therefore appears as a band . . ." There are 14 plates of excellent photomicrographs (although the authors insist on calling them microphotographs, pp. 77 and 89). It is unfortunate the plates were not numbered or labelled in some way so as to facilitate correlating them with their descriptions.

—*E. F. Paddock.*

The Handling of Chromosomes, by C. D. Darlington and L. F. LaCour. The Macmillan Co., New York, 1941. 165 pp., 14 pl., 7 figs. $2.50.

AN ECOLOGICAL STUDY OF THE WORM PARASITES OF PORTAGE LAKES FISHES

ROBERT C. HARE
University of Akron, Akron, Ohio

During the years of 1939 and 1940 a taxonomic and ecological study was made of the worm parasites of the fishes of the Portage Lakes, near Akron, Ohio. The complete results of this work are presented in an unpublished thesis (Hare, 1941) of which the present paper is a summary.[1]

We have attempted to bring out in this work not only the kinds of worms found in each host, but also to show the various ecological factors involved, e.g., the effect of season, habitat, age, and food relations on parasitism.

The Portage Lakes comprise a chain of small lakes and reservoirs extending southward from the city of Akron, Ohio. Summit Lake is within the city. Nesmith Lake, 41 acres, depth 10–24 feet; North Reservoir, 136 acres, depth 4–12 feet; East Reservoir, 292 acres, depth 12–25 feet; and Turkeyfoot Lake, 531 acres, depth 10–50 feet, were the principal lakes from which collections were made. The group includes also Long Lake, West Reservoir, and smaller tributary lakes as Hower's Lake from North Reservoir, Mud Lake and Rex Lake from Turkeyfoot. There is also small, shallow, weedy Grape Lake. Further to the south is the still larger, newly formed Nimisila Reservoir. A few specimens were also taken from the Ohio Canal, part of which connects Summit Lake with Nesmith Lake. The shore line of the chain offers a great variety of conditions from cottage-lined banks to large marshy areas. The lakes and fish conditions were reported on by Osburn (1921), and studies of fish food and plankton were made by Kraatz (1928, 1931, 1941).

Acknowledgment of indebtedness of the author goes to Paul Eschmeyer for collections of fish and their identification; Dr. R. V. Bangham for identification of many parasites; Fred H. Glenny for assistance in preparing slides of parasites; Samuel Caplin for photographs of parasites (not included in this paper), and Dr. Walter C. Kraatz for suggestions and help in the work and the thesis and this paper.

COLLECTIONS AND PREPARATION

Fish were caught over a period of a year by set net, seine, and hook and line from all possible ecological habitats and examined fresh immediately or after icing.

All worm parasites were removed while alive and kept for study in a 0.7% $NaHCO_3$ solution (Van Cleave and Mueller, 1934). Fish were examined singly by hand; each organ removed to separate dish of soda solution; parasites removed and freed of mucus in fresh solution.

Several killing and fixing agents were employed. Nematodes were put in hot 70% alcohol; Cestodes and Trematodes in hot Bouin's fluid, 12–24 hours, and later placed in 70% alcohol. Leeches were also fixed in Bouin's, and Acanthocephala were placed in tap water whereupon their beaks extended, and then fixed in Bouin's.

Most of the worms were stained and mounted in toto, using para-carmine or borax carmine, and cedar oil for clearing. Some fish livers were sectioned to reveal smaller parasites, staining with Ehrlich's haematoxylin and eosin.

[1]The thesis was in partial fulfillment of the requirements for the degree Master of Science, University of Akron, 1941. Due to the entrance of Robert C. Hare into the U. S. Army, Dr. Walter C. Kraatz collaborated in the production of this paper.

The total number of fish examined for all worm parasites was 127, or 21 species, falling in 8 families. These are listed in the course of the paper. This is somewhat less than half of all the recorded fish species of the lakes. Of the 29 species not taken, 17 are minnows, 4 catfish, and 5 sucker species.

THE PARASITES, THEIR ABUNDANCE AND DISTRIBUTION IN RELATION TO HOSTS

Parasites found belong to Trematoda, Cestoda, Nematoda, Acanthocephala and Hirudinea.

Trematoda.—Ectoparasitic Trematodes, order Monogenea, were not represented. All those found were of Order Digenea, which require a snail as host for prior larval stages. There are two possible conditions: (1) those which attain maturity in the fish (then chiefly in the digestive tract), (2) those which are immature in the fish (metacercariae) to reach functional maturity only after being eaten by a fish-eating bird or mammal—or possibly some second predator fish or other aquatic vertebrate.

Allocreadium sp.—Three specimens were found in intestine of the common sunfish from shallow water over mud bottom in the Ohio Canal.

Microphallus Ward, 1901.—*Microphallus opacus* was found only in one rock bass, taken August 1 in shallow, weedy water of the Ohio Canal. About a dozen of the worms were present in stomach and intestine. Crayfish are said to carry the metacercaria in their liver (Ward, 1894). It may be significant that the rock bass host had a large crayfish in its stomach. Four of the nine specimens in the stomach were still metacercariae.

Strigeidae.—Those found were all of the larval group *Neascus*, well described by Hughes (1927). All occur in fish as encysted metacercariae.

Neascus vancleavii (Agersborg, 1926).—This parasite was found encysted in internal organs of various Centrarchidae, in moderate to heavy infestations. The common sunfish was very susceptible. The liver was infested with hundreds of the larvae. Most parasitized fish were from shallow water. The age of the fish seems to have bearing on Neascus infestation, at least in the bluegill. Of 14 of these under 4 inches from various localities in the lake, none were infested, but of the five larger bluegills, three were heavily infested. Some hybrids of common sunfish and bluegill were only lightly infested. Other hosts were the large-mouth black bass, warmouth bass.

Neascus ambloplitis Hughes (1927).—This common parasite occurs as a deeply pigmented integumentary cyst, forming a slight elevation; often a fish appears literally peppered with them. All the infested fish were from shallow water. Heaviest infestations were found in perch, log perch, large-mouth bass; less in warmouth bass, long-eared sunfish and steel-colored minnow. Perch were seldom found without the cysts. Only young of the large-mouth bass were infested. Of ten bass under four inches from various parts of the lakes, nine were infested, whereas of nine over four inches, none were infested.

Cestoda.—Adults of fish tapeworms always occur in the alimentary canal of the fish. There is more flexibility of host species than in Trematodes, and also in host relations in larval stages. Larvae usually develop in Arthropods. In addition to serving as hosts for adult tapeworms, fishes frequently shelter advanced larvae which reach maturity in other fishes, amphibia, reptiles, birds or mammals.

Cestoda do not occur as abundantly as Trematoda or Acanthocephala in Portage Lakes fishes.

Proteocephalus, La Rue, 1914; *Proteocephalus ambloplitis* (Leidy).—This is the most common species of cestode in Portage Lakes fishes. It was found in the

digestive tract of all five of the garpike examined and in the stomach of the large-mouth bass. Larval forms were found in the liver, gonads and body cavity of the garpike and bluegills and in the pericardial cavity of the bass. These larvae have been known to cause economic loss because of infestation of gonads of hatchery bass. Bangham (1927) refers to it as "a most serious handicap to the hatching of bass."

Copepods have been shown (Hunter, 1928) to serve as first host for *P. ambloplitis*. Van Cleave and Mueller (1934) state that Proteocephalus is of general distribution. Young fish seem less susceptible. All of the parasites were from mature fish.

Proteocephalus fluviatilis Bangham (1925).—Eight adults of this species were taken from one large-mouth black bass, caught May 23 in deep water in East Reservoir.

Proteocephalus singularis La Rue (1911).—This species, both as larvae and adults, occurred in the stomach of the long-nosed gar. In one instance over a hundred were taken from one host. All the fishes were from deep water.

Corallobothrium Fritsch; *Corallobothrium fimbriatum* Essex (1928).—Four worms of this species were found in the intestine of one mature black bullhead caught in January through the ice of Grape Lake.

Nematoda.—Roundworms were less frequently encountered than preceding group in Portage Lakes fishes.

Contracaecum Raillet and Henry.—The genus belongs to the Ascaroidea. *Contracaecum* sp.—Numerous larvae were encysted in the walls of the intestine and in mesenteries of two black bullheads caught January 1 through the ice of Grape Lake.

Philometra Costa.—The genus belongs to the order Filarioidea. *Philometra cylindracea* Ward and Magath (1917)—A single adult female of this roundworm was taken from the intestine of a rock bass August 1, from the shallow water of the Ohio Canal.

Acanthocephala.—Thorny-headed worms were found to be the most abundant worm parasites of fishes in this study, although only three species of these parasites were found.

Neoechinorhynchus Hamann; *Neoechinorhynchus cylindratus* (Van Cleave, 1913).—This worm occurred in great abundance in the large-mouth black bass, crowding the intestine. It was found in both young and old fish, the severity of the infestation increasing with age. Although many different hosts are given for this species by various workers, in this study it was not found outside of the bass, except for one instance of larvae encysted in liver of a common sunfish.

Leptorhynchoides thecatus (Linton, 1891).—This parasite was the most abundant of the Acanthocephala, and of all the worm parasites of Portage Lakes fishes. It was widely distributed in fish species, commonest in large-mouth black bass, bluegill; next commonest in hybrid sunfish, common sunfish, warmouth bass, and found also in other Centrarchidae and occasionally in other fishes. It occurred in stomach and intestine, sometimes so numerous in a host as to clog the intestine and tear the walls, and sometimes found in the coelom. Older hosts were more heavily infested.

In life cycle studies, Van Cleave (1920) showed that larvae lived in the Amphipod *Hyalella knickerbockeri*. This amphipod is also abundant in the Portage Lakes. It appears that larvae from these arthropod hosts swallowed by the fish may, presumably if too small, bore through the fish intestine wall and proceed with larval growth in a cyst within the viscera. Such encysted larval stages were found in various internal organs. Thus a fish may become an additional intermediate host.

Pomphorhynchus Monticelli; *Pomphorhynchus bulbocolli* Linkins.—This species was less abundant than the other two species but rather widely distributed. It was found chiefly in the goldfish and black bullhead, but also in yellow perch, long-eared sunfish, warmouth bass. It was in the intestine, except also in gonads in goldfish.

The Acanthocephala are so abundant in most hosts as to cause serious damage. This has been discussed by Bangham (1928), Van Cleave (1919), and Pearse (1924). The damage to fishes in the present collections was often evident. When the intestinal lumen was clogged, laceration of walls with holes was frequent, resulting in inflammation and yellowing of the tissues.

Acanthocephala seem to be well adjusted to their parasitic existence. There is no free-living stage. Two hosts are always required. Larval hosts are Insects or Crustacea. (Van Cleave and Mueller, 1934). Since host-parasite relationship is not very specific, adults may be in many species of fishes, passing from one to another as a predator eats a small fish. A large predator might adopt the Acanthocephala of several host victims. This was shown in this study of the Centrarchidae of the Portage Lakes. All the Centrarchidae showed high percentage of infestation, except the white crappie. Practically every specimen of the others was infested heavily. In six white crappie no Acanthocephala were found. The identifiable stomach contents of the white crappie (six specimens) were the fry of gizzard shad, *Dorosoma cepedianum*, which is a fish now well known to feed almost exclusively on phytoplankton (Tiffany, 1921), and sometimes on bottom mud. This parasitically sterile fish, when serving as the food of white crappie, explains the nearly complete lack of parasitism of the crappie in the present instance.

Seasonal periodicity of Acanthocephala infestation was also noted. Winter fish collections were almost devoid of these worms of adult stage. The hosts feed little in the winter. Acanthocephala may overwinter more as larval forms.

Hirudinea.—Leeches are of relatively minor importance as fish parasites. A total of only four leeches were found on fish taken in this study. One of these was a leech of genus *Illinobdella*, from the skin of a warmouth bass, caught through the ice in February in Grape Lake, which is very shallow. The other three were not identified and were found on gills of black bullhead, and the roof of the mouth of a long-eared sunfish from the Ohio Canal, and the other from the fin of a bluegill from North Reservoir. There was no correlation between infestation and season or habitat type.

CORRELATION OF PARASITISM AND HABITAT

Because of the small areas involved, the differentiated habitats are not extensive, so that many fish may not be so fully restricted to one habitat. But they have their individual environment preferences. Some parasites also appear to have such restricted habitats, which is probably determined chiefly by the range of the intermediate hosts.

Parasitism occurs more in shallow than deep water; 28% of the fish taken in deep, open water were parasitized, but 73% of the fish taken in shallow water were infested. Of shallow water fish, 27% were infested with Trematodes, but only 4% from deep water had Trematodes. However, Cestodes were found in 44% of deep water fish and only 3% of shallow water fish, and thus in contrast to the other parasites.

Acanthocephala were predominately in the shallow water association, 56% of fish in shallow water as contrasted to 32% in deep water were infested. The fish taken from a hard bottom habitat were 95% infested with Acanthocephala; those taken from a soft bottom habitat were 44% infested.

In fact, hard-bottom, shallow-water habitat fish had the greatest infestation throughout, double that of the shallow-water, mud-bottom habitat fish and not quite double that of the deep-water, mud-bottom habitat fish, in latter of which tapeworms raised the percentage of infestation. Probably the explanation is largely that the carnivorous fish like Centrarchidae were mostly taken in the hard-bottom shallow water.

TABLE I

Percentage of Parasitism in Fish Families and Species

Family of Fishes	Number Examined		Percent Infested	
Species and Common Name	Fam.	Sp.	Fam.	Sp.
Lepisosteidae	5		100	
Lepisosteus osseus, long-nosed garpike		5		100
Clupeidae	7		0	
Dorosoma cepedianum, gizzard shad		7		0
Cyprinidae	16		18.7	
Cyprinus carpio, carp		1		100
Carassius auratus, goldfish		1		100
Notropis whipplii, steel-colored minnow		1		100
Notemigonus crysoleucas, golden shiner		6		0
Hyborhynchus notatus, blunt-nosed minnow		7		0
Ameiuridae	5		80	
Ameiurus melas, black bullhead		5		80
Esocidae	1		100	
Esox vermiculatus, grass pike		1		100
Percidae	11		36.4	
Perca flavescens, yellow perch		3		66.6
Percina caprodes, log perch		8		37.5
Centrarchidae	66		89.7	
Huro salmoides, large-mouth black bass		19		100
Lepomis macrochiarus, bluegill		19		94.7
Eupomotis gibbosus, common sunfish		8		100
L. machrochiarus x *E. gibbosus*, hybrid sunfish		4		100
Ambloplitis rupestris, rock bass		1		100
Chaenobryttus gulosus, warmouth bass		7		71.4
Pomoxis annulairs, white crappie		6		16.6
Pomoxis sparoides, black crappie		1		100
Xenotis megalotis, long-eared sunfish		1		100
Atherinidae	16		0	
Labidesthes sicculus, brook silversides		16		0

AMOUNT OF PARASITISM IN THE FISHES

From the ecological point of view one is interested in the species of parasites a host harbors, the relative abundance of the parasite species, and also in the percentage of host specimens infested. Kinds of parasites and relative abundance have been presented above, together with relations of fish species. There is no room for detailed data for every fish examined, but a list of fishes, grouped by families, is given here (Table I), showing percentage of infestation of the fish species.

DEGREE OF PARASITISM WITHIN THE FISH FAMILIES CORRELATED WITH FEEDING HABITS

Of the total fish taken, 127, the number infested with one or more kinds of worm parasites was 76, or a percentage of 59.8, which by coincidence at least is practically the same as the 58.3% on a much larger number of Lake Erie fish, 2,156, found by Bangham and Hunter (1939). Essex and Hunter, 1926, working in the Central States, obtained a 39% infestation in 652 fish examined.

The number of fish examined is admittedly very small, especially for some species, but it seems that the data should give some idea of the fish parasite relation of many of the fish types of these inland lakes.

Consideration of the fishes by families is of some significance and allows for some generalization. It is not that phylogenetic relationship is of dominant importance, but food habits naturally are important in the matter of securing parasite infection and thus important for all fishes of a family having similar food habits. Where there is a striking exception, it can be seen that the difference in food accounts for the difference in parasites. Such is the case in the white crappie, utterly free of Acanthocephalan parasites, whereas all other Centrarchidae were heavily infested. (The percentage in the table for white crappie is due to a very light infestation of one of the six with a different but unidentified parasite.)

The families with high percentage of infestation are Lepisosteidae (100%), Ameiuridae (80%), Esocidae (100%), and Centrarchidae (89.7%).

The data on food of every fish taken was kept, but space limitation prevents inclusion here.

The records on Lepisosteidae and Esocidae are based on meagre catches here, but their food habits are well known. Ameuridae may have more versatile food habits, but the five black bullheads contained chironomid larvae and snails only. The food of all the 66 members of Centrarchidae was comprised of fish, crayfish, snails, chironomids and other insects, and some Cyclops and Cladocera in some young specimens. They were predominantly carnivorous.

These families included the so-called game fishes and similar forms.

One family, Percieae, more intermediate in degree of parasitism, comprises fish of versatile food habits.

The three families least parasitized were Clupeidae (0%), Cyprinidae (18.7%), and Atherinidae (0%). These are definitely non-game fishes.

The gizzard shad of the Clupeidae (already referred to) feeds largely on phytoplankton and may take some mud. The Atherinidae feed primarily on plankton, (Sibley, 1929). Many of the Cyprinidae are known to be bottom feeders and scavengers and to a large extent feed also on plankton. For example, the blunt-nosed minnow is typical as well as versatile, as shown in a food study from these same waters, (Kraatz, 1928).

It is clear that those fishes whose main diet is plankton and especially those feeding on phytoplankton, and bottom materials, show no parasitism or low degree of parasitism.

CORRELATION OF PARASITISM WITH AGE OF HOST

The parasitic fauna often changes markedly with age, a consequence of changing food habits. Most fish feed on minute Crustacea and other plankton when young, thus acquiring those parasites which utilize some of the smaller Arthropods as hosts, such as the Acanthocephala. As the fish grows older, if carnivorous, it begins to capture larger animal forms and then becomes exposed to other parasitic worms, such as trematodes and cestodes. Data are here presented for the bluegill and large-mouth black bass. The Acanthocephalan *Leptorhynchoides thecatus* is found in both the young and mature bluegill and bass. The cestodes and trematodes occur only in the more mature bluegills. In the large-mouth bass, however,

Neascus ambloplitis appears primarily as a parasite of the immature fish, although the cestode *Proteocephalus ambloplitis* is found only in the older fish. Because of their larger size and more voracious appetite the large-mouth bass might be infested by trematodes while still relatively young.

TABLE II

Effect of Age on Parasitism

Figures show percent of fish infested

Parasite	Bluegill		Largemouth Bass	
	Under 4″	Over 4″	Under 6″	Over 6″
L. thecatus	91	88	77	100
P. ambloplitis	0	25	0	50
N. vancleavii	0	25	8	17
N. ambloplitis	0	17	69	0

SUMMARY

A total of 127 fish, representing 21 species of 8 families, were taken from the Portage Lakes.

Parasites were studied. Most were endoparasites, a few leeches being the only ectoparasites. The classes Trematoda, Cestoda, Nematoda, Acanthocephala were represented; the Nematoda least of these.

Acanthocephala, with *Leptorhynchoides thecatus* in intestine, strikingly abundant, were the most common and widespread parasites. *Neoechinorhynchus cylindratus* was second in abundance of thorny-headed worms.

The trematode, occurring as metacercariae, *Neascus vancleavii* was also often abundant in liver and *Neascus ambloplitis* as a skin encysted parasite.

Shallow water fish exhibit a higher degree of parasitism than deep water fish and those from a hard bottom more infested than those of a mud bottom. But Cestodes were commoner in deep water fish.

Food habits have a marked relationship with parasitism. Families Clupeidae, Atherinidae and Cyprinidae, which are more herbivorous and bottom and general feeders, had a collective percentage of parasitism of only 7.7%.

The five other families, Lepisosteidae, Ameiruidae, Esocidae, Percidae, and Centrarchidae, showed a collective infestation of 83.5%. These are chiefly carnivorous, and many of them game fishes. The Percidae were least infested of these five, and they are less carnivorous than the other four families.

There is some correlation of parasitism with age of host, parasitic fauna changing with the changing food habits of the growing fish.

Of the 127 fish, 76 or 59.8% harbored one or more species of worm parasites.

LITERATURE CITED

Agersborg, B. P. K. 1926. Studies on the affect of parasitism upon the tissues. II. With special reference to a new Diplostomous trematode found in the minnow *Notropis anogenus* Forbes. Arch. f. Schiffs-u. Tropen-hyg., 30: 18–30.

Bangham, R. V. 1925. A study of the cestode parasites of the black bass in Ohio, with special reference to their life history and distribution. Ohio Jour. Sci., 25: 255–262.

1927. The life history of cestode *Proteocephalus ambloplitis*. Trans. Amer. Fish Soc., 47: 206–208.

1928. Parasites of black bass. Sci., No. 27: 267–270.

1928a. Distribution of parasites of black bass in lakes and streams of Ohio. Ohio Cons. Bull., 17.

Bangham, R. V., and **Hunter, G. W., III.** 1939. Studies of fish parasites of Lake Erie. Distribution studies. Zoologica, 24: 385–448.
Essex, H. E. 1928. The structure and development of Corallobothrium with descriptions of two new fish tapworms. III. Biol. Monogr., II (3): 1–75.
Essex, H. E., and **Hunter, G. W., III.** 1926. A biological study of fish parasites from the Central States. Trans. Ill. Acad. Sci.
Hare, Robert C. 1941. An ecological study of the worm parasites of Portage Lakes Fishes. (Unpublished thesis, University of Akron.)
Hughes, R. C. 1927. Studies on the trematode family Strigeidae (Holostomidae) VI. A new Metacercaria Neascus ambloplitis, sp. nov., representing a new larval group. Trans. Amer. Micros. Soc., 46: 248–267.
Hunter, G. W., III. 1928. Contributions to the life history of *Proetocephalus ambloplitis* (Leidy). Jour. Parasitol., 16: 229–242.
Kraatz, W. C. 1928. Study of the food of the blunt-nosed minnow, *Pimephales notatus*. Ohio Jour. Sci., 28: 2: 86–98.
1931. A quantitative net-plankton survey of East and West Reservoirs, near Akron, Ohio. Ohio Jour. Sci., 31: 6: 475–500.
1941. Quantitative Plankton studies of Turkeyfoot Lake, near Akron, Ohio. Ohio Jour. Sci., 41: 1: 1–22.
La Rue, G. R. 1914. A revision of the cestode family Proteocephalidae. III. Biol. Monogr., 1: 1–350.
Linton, R. 1891. A contribution to the life cycle of *Dibothrium cordiceps*, a parasite infesting the trout of Yellowstone Lake. Bull. U. S. Fish Comm., 9: 337–358.
Osburn, R. C. 1921. Report on the fish conditions in the Portage Lakes. Ohio Sportsmens Bull. I.
Pearse, A. S. 1924. Observations on parasitic worms from Wisconsin fishes. Trans. Wis. Acad. Sci., Arts, Letters, 21: 147–160.
Sibley, C. K. 1929. The food of certain fishes of the Lake Erie drainage basin. Suppl. 18th Ann. Rept. N. Y. State Cons. Dept., 1928: 180–188.
Tiffany, L. H. 1921. Algal food of the young gizzard shad. Ohio Jour. of Sci., 21: 113–122.
Van Cleave, H. J. 1913. The genus Neoechinorhynchus in North America. Zool. Anz., 43: 177–190.
1919. Acanthocephala from the Illinois River, with descriptions of species and a synopsis of the family Neoechinorhynchidae. Bull. Ill. Nat. Hist. Surv., 13: 222–257.
1920. Notes on the life cycle of two species of Acanthocephala from fresh-water fishes. Jour. Parasitol., 6: 167–172.
Van Cleave, H. J., and **Mueller, J. F.** 1934. Parasites of Oneida Lake fishes. Part III. A biological survey of the worm parasites. Roosevelt Wild Life Annals, 7: 159–335.
Ward, H. B. 1894. Some notes on the biological relations of the fish parasites of the Great Lakes. Proc. Neb. Acad. Sci., 4: 8–11.
1901. Notes on the parasites of lake fish. III. On the structure of the copulatory organs in Microphallus nov. gen. Trans. Amer. Mic. Soc., 22: 175–187.
Ward, H. B., and **Magath, T. B.** 1917. Notes on some nematodes from fresh-water fishes. Jour. Parasitol., 3: 57–64.

A Survey of Biology

This book provides an excellent organization of subject matter that might be included in a survey course of biology for underclassmen of colleges or universities. It can also be recommended to the layman who desires a general cultural knowledge of biology and its integration with liberal education. It is refreshing to find that a book of this scope can be written about the broad generalizations necessitated by its functions and yet make little or no sacrifice of the accurate factual information upon which these biological principles must be based. The four chief subdivisions concern the organism in its aspects as 1) an individual, 2) a member of its race, 3) a product of evolution and 4) a unit in a social-economic complex. The first subdivision discusses the structures and functions of the human body and this is followed by a similar analysis of a typical seed plant. This section as well as that on evolution is outstanding, giving one an excellent picture of man's position in this world of living things. Perhaps some biologists, including this reviewer, would desire more emphasis on human inheritance, taxonomic relationships, and the broader aspects of ecology such as geographical distribution, social behavior, conservation, personal and public health programs. The physical make-up of the book is attractive and there are sufficient illustrations. The appendix includes a brief survey of the plant and animal kingdoms, general references and a glossary.—*J. G. Haub.*

Man and the Biological World by J. Speed Rogers, Theodore H. Hubbell and C. Francis Byers. 607 pp. New York, The McGraw-Hill Co., 1942. $3.50.

A NEW PRAIRIE SPIDER

W. M. BARROWS
Department of Zoology and Entomology,
Ohio State University

Many years of careful collecting in the prairie regions of the State of Ohio have yielded several new species of spiders. Among them is the following:

Souessa nasuta n. sp.

Male.—Length 1.8 mm. The thorax is dull yellow suffused with sooty black. The legs and basal segments of the palps are light yellow. The projecting clypeus is light yellow above and below. The sternum is dull yellow heavily covered with sooty black. The abdomen is light yellow dusted with sooty black giving the appearance of being dull green. The sooty covering is speckled with tiny pin points of yellow and crossed by many bright rays of yellow which for the most part are directed laterally or posteriorly. Starting between the second pair of muscle impressions is a narrow sooty line which runs backward becoming narrower. The venter of the abdomen is dull green with two light boundary streaks which bow outward. The spiracle is marked by a long light colored procurved line which is expanded at the ends.

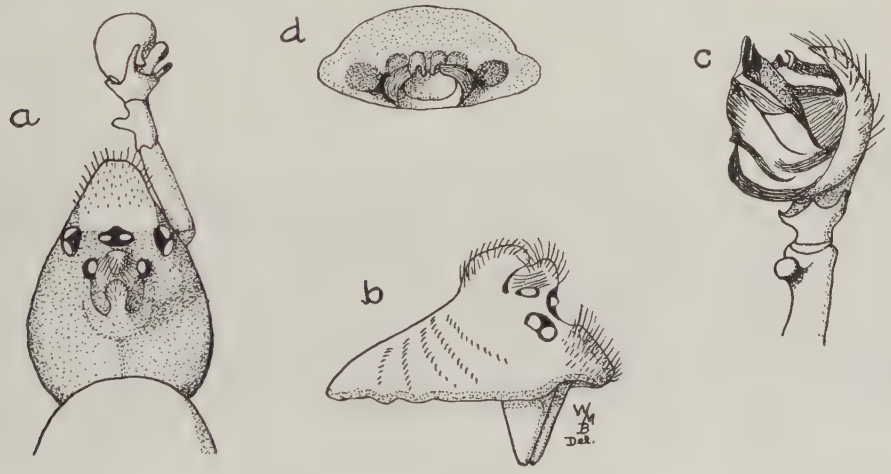


FIG. 1. *Souessa nasuta* Barrows. a. Dorsal view of male. b. Side view of male cephalothorax. c. Palpal organ of male. d. Epigynum of female.

The palpal organ is much like that of *Souessa spinifera* Camb.[1] except that the two terminal teeth are twisted around each other. The patella of the palp carries on its distal end a spur which projects downward and inward (Fig. 1, a and c).

Fig. 1, b shows a lateral view of the male cephalothorax.

Female.—Length 1.9 mm. The colors and markings are the same as the male in every detail. The head is normal except that the clypeus is high, broadly rounded in front, and flares forward and outward.

The epigynum is shown in Fig. 1, d.

Two males in prairie northwest of West Jefferson, Ohio. Sept. 23, 1923.

Five females from the same place Oct. 19, 1924.

[1]Crosby and Bishop, Festschrift für Embrik Strand. Riga, 1936–37, II, p. 57.

A NEW SPECIES OF ASTRAEOSPONGIA FROM THE MIDDLE DEVONIAN OF OHIO

JOHN W. WELLS,
The Ohio State University, Columbus, Ohio

In the course of a study of the Middle Devonian bone beds of Ohio and adjoining states a rich thanatocoenotic microfauna has been found in them, including many new types of skeletal parts of fishes together with lesser numbers of conodonts, ostracods, and foraminifera. Spicules of sponges are much rarer than other remains and all that have been found so far seem to pertain to a new species of the peculiar octactinellid, *Astraeospongia*, described below.

Family OCTACTINELLIDAE

Genus **Astraeospongia** Roemer 1860

Astraeospongia ohioensis n. sp.

(Figures 1–4)

Description.—Known only from isolated beekitized spicules. Two specimens (Figs. 1, 2) have six horizontal rays and two vertical ones, the latter equal in length to the horizontal ones. In two other specimens (Figs. 3, 4) the vertical rays are mere protuberances scarcely one-fifth the length of the horizontal rays. Total diameter across opposite horizontal rays, 1 to 1.5 mm. Rays club-shaped or bluntly cylindrical, about 0.25 mm. thick, fixed to a well-developed central disc.

Astraeospongia ohioensis, n. sp.

FIG. 1. Holotype (O. S. U. No. 19486), Columbus ls. bone bed, Marion Co., O.; 2, O. S. U. No. 19485, Columbus ls. bone bed, Franklin Co., O.; 3, O. S. U. No. 19487, Columbus ls. bone bed, Crawford Co., O.; 4, O. S. U. No. 19488, upper Columbus ls., Ottawa Co., O. All spicules enlarged 25×.

Occurrence and Material.—(a) In the bone bed at the top of the Columbus formation at the following localities: (1) J. and L. Snouffer quarry, east side of Scioto River, one mile south of Dublin, Franklin County, Ohio (1 specimen, O. S. U. 19485); (2) J. M. Hamilton and Sons quarry, east of highway 1.75 mi. north of Marion, Marion County, Ohio (2 specimens, including holotype, O. S. U. 19486); (3) National Lime and Stone Co. quarry on Broken Sword Creek, 1 mi. northwest of Spore, about 6 mi. northwest of Bucyrus, Crawford County, Ohio (1 specimen, O. S. U. 19487).

(b) In the uppermost part of the Columbus formation in a road cut on the south side of Marblehead peninsula 2.5 mi. west of south of Lakeside, Ottawa County, Ohio (1 specimen, O. S. U. 19488).

Remarks.—This form is marked by the small size of the spicules which are on the average less than half as big as those of other Devonian species. In *A. devoniensis* Hinde (1887, p. 140, pl. 4, figs. 8–8c) from the Middle Devonian of Devonshire, the spicules are larger (2.5 to 5 mm.), with thinner, longer, more attenuate rays. *A. meniscoides* Dewalque (1872, pp. 23–26, pl. 1) from the Middle Devonian of Belgium and the Eifel, has larger spicules (4 mm.) with no vertical rays and fusiform horizontal rays. *A. hamiltonensis* Meek and Worthen (1868, p. 419, pl. 10, fig. 6) from the Middle Devonian of Iowa, also has larger spicules (3.25 mm.) that seem to lack vertical rays and with horizontal ones 0.5 mm. in thickness and 1.5 mm. long. In *A. rhenanum* (Schlüter) (1887, p. 23, pl. 2, figs. 7–9), from the Middle Devonian of the Eifel, the spicular rays are relatively very long and slender, needle-like, 0.2 to 0.4 mm. thick, the total diameter of the spicules being 3 or 4 mm.; the central disc is very small and the vertical rays well-developed.

REFERENCES CITED

Dewalque, G. 1872. Un spongiaire nouveau, du système eifelien. Acad. Roy. Belgique, Bull., 34: 23–26, pl. 1.

Hinde, C. J. 1886–1911. Monograph of the British fossil sponges. Vol. 1, Sponges of Palaeozoic and Jurassic Strata. Palaeont. Soc. London, pp. 1–92; pls. 1–8 (1886); 93–188, pl. 9 (1887); 189–254, pls. 10–19 (1893); 255–264 (1911).

Meek, F. B. and Worthen, A. H. 1868. Fossils of the Hamilton group. Geol. Surv. Illinois, 3: 419–449, pls. 10–13.

Schlüter, C. 1887. Ueber Scyphia oder Receptaculites cornucopiae Goldf. sp. und einige verwandte Formen. Zeitschr. d. g. Ges., 39: 1–26, pls. 1–2.

Ways of the Weather

Everyone talks about the weather and no one can do anything about it. In a scholarly treatise Humphreys, a veteran weatherman of forty years experience, gives a comprehensive discussion of its various aspects. He presents only the most elementary knowledge of the weather by his readers, and discusses in detail not only such subjects as Structure of the Atmosphere, Distribution of Temperature, Water Vapor and Atmospheric Pressure, Wind and Precipitation, but also the meteorological instruments employed and gives considerable history of the science. Of special interest are the chapters on such unusual subjects as Weather Music, Weather Perceptions, Atmospheric Electricity and Atmospheric Optics.

The literary style employed is of an unusually fine quality. The author does not hesitate to use rhyme and verse when appropriate. For example, "even the big eddies have smaller eddies upon them and the smaller eddies lesser eddies. As L. F. Richardson puts it,

'Big whirls have little whirls that feed on their velocity,
And little whirls have lesser whirls and so on to viscosity.' "

The reader gains the impression that the writer knows what he is talking about, and that he has not sacrificed scientific accuracy on the altar of popular appeal. Indeed, the seeker of easy and complete answers may be disappointed in this book. It is not light reading and in some instances the gleaning of worthwhile information is made tedious by unnecessary details.

The volume is attractively bound and a splendid grade of paper is used. It is replete with excellent illustrations. Anyone interested in the "ways of the weather," and this includes most of us, should find this book an illuminating reference.—*D. C. Rife.*

Ways of the Weather, by W. J. Humphreys, the Jaques Cattell Press, Lancaster, Pa., 1942. $4.00.

Ohioans in Aviation

Dayton, Ohio, is the place where Wilbur and Orville Wright were born and lived the greatest part of their lives. It was here that they designed and conducted the first wind tunnel experiments in history. The principles thus scientifically discovered enabled them to succeed where others had failed. The real achievement of this book, however, is not a eulogy on the significance of their activities. It is an interesting, well documented account of the experiences and personal reactions to them which the Wrights had. Such an intimate personal analysis was possible only because Orville Wright himself participated by making a mass of original documents available to the author, by reading the entire manuscript, and by suggesting corrections. Here is the true story of the Wright Brothers as they lived it.—*Elton F. Paddock.*

The Wright Brothers, by Fred C. Kelley. Harcourt, Brace and Company, New York, 1943. 340 pp. $3.50.

TWO NEW ULOTRICHALES

EDGAR N. TRANSEAU
Department of Botany, The Ohio State University,
Columbus, Ohio

Following are descriptions of two new species of green algae that are of interest because each contributes to our concept of the genus to which it belongs. Both descriptions have been held for some years in manuscript form in the hope that the plants might be studied cytologically before publication.

Chaetonema ornatum sp. nov.

Filaments straight or irregular, with shorter lateral branches more or less at right angles to the filament, imbedded in the pectic sheath of *Tetraspora* and *Draparnaldia*. Vegetative cells at

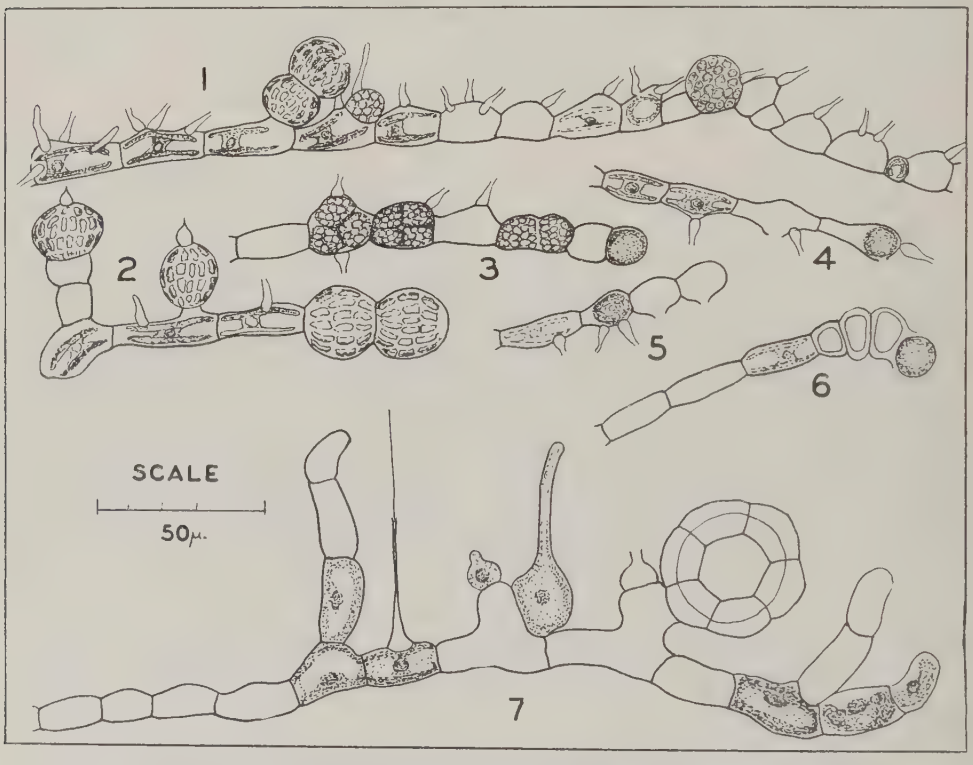


FIG. 1. *Chaetonema ornatum*, filament with vegetative cells, 2 antheridia and 2 oogonia. FIG. 2. Part of a filament with mature oogonia only. FIG. 3. A filament with antheridia and sperm masses, also a terminal sporangium containing a swimming spore. FIGS. 4, 5, and 6. Vegetative cells and sporangia with swimming spores. FIG. 7. *Coleochaete sampsonii*, filament with seta, immature antheridium and oögonium, and mature oögonium.

first 7 to 10μ in diameter, and 15 to 30μ long, later becoming enlarged toward the middle to 14 to 20μ, often with one to four rather short setae. Reproduction by swimming spores, one or two of which may be formed within an enlarged vegetative cell. Development of two spores follows immediately after division of the protoplast, with or without the formation of a separating wall. The spores are 11 to 15μ in diameter.

Sexual reproduction occurs by the union of eggs and sperms formed in oögonia and antheridia. The oögonia usually develop singly, or in pairs, on lateral branches, or from the terminal cells of main filaments. Oögonia are nearly globose, 18 to 22μ in diameter, with or without a terminal seta. Occasionally the oögonia are ovoid and up to 28μ long. The oögonial wall is marked by oblong pits, arranged more or less zonally.

Antheridia form in cells, either of the main filament or of lateral branches, either before a principal division of the protoplast occurs, or following one or two divisions. Each daughter protoplast then divides internally, and apparently 32 to 128 sperms result.

Apparently the plant is monoecious, but there are filaments present in the material that are forming only antheridia, others only oögonia, and still others only swimming spores.

This species was first collected on *Tetraspora*, from a pond near Birmingham, Alabama, April 11, 1925. In 1941 and 1942 it was again found by Dr. Elwyn Hughes in Halifax, Queen's and Lunenberg counties, Nova Scotia, where it was epiphytic on *Tetraspora* and *Draparnaldia*.

Thallus epiphyticus, e filamentis irregulariter ramosis; ramuli rectangulariter exeuntes, distantes. Cellulis vegetativis vel subcylindricis vel unilateraliter inflatis; 1–4 setas gerentibus, 7–10μ latis, 2–4– plus longioribus; oogoniis subglobosis 18–22μ latis. Fig. 1–6.

Coleochaete sampsonii sp. nov.

During August, 1932, Dr. Homer C. Sampson collected algae in the vicinity of the Fulton Chain of Lakes in the western Adirondacks, New York. Among the collections were several vials containing species of *Batrachospermum* from Quiver and Round Lakes. In the surface of the pectic sheaths there were large numbers of a small and very simple *Coleochaete* resembling *C. pulvinata* in its mode of branching. In August, 1933, the plants were again found in abundance and this material contains all stages in the development of the reproductive organs. In the summer of 1934 the lakes were extremely low and the banks were exposed to the air and no specimens were found. In September, 1935, the water was unusually high and neither the *Batrachospermum* nor the *Coleochaete* could be found at any of the former localities, possibly because of previous fluctuations in the water levels. The species differs from *C. pulvinata* in its smaller dimensions, its spheroidal oöspore and the simplicity and regularity of the cortication of the oögonium. Following are the characteristics of this species:

Monoecious, filaments branching, prostrate, very irregular; cells 7 to 14μ x 14 to 36μ, irregularly curved, cylindric or enlarged near the middle; young oögonium with an elongated trichogyne; mature oögonium globose, corticated, 35 to 38μ in diameter; antheridia small globose or pyriform cells that arise laterally from the vegetative cells; oöspore 29 to 36μ in diameter. Fig. 7.

Thallus epiphyticus, e filamentis varie ramosis; cellulis vegetativis 7–14μ latis, 14–36μ longis, irregulariter curvatis, vel cylindricis vel in medio tumidis; oogoniis globosis, corticatis, diametro 35–48μ oosporis globosis diametro 29–36μ; antheridiis vel globosis vel piriformibus.

Blood Groups and Transfusion

The third edition of Blood Groups and Transfusion is a comprehensive and authoritative treatise of the subject. It is a notable improvement over and enlargement of the second edition. Two new chapters have been added, one dealing with the transfusion of stored blood and blood substitutes, and the other with the Rh factor. So many changes were made in the other twenty chapters that the book was reset from new type. Detailed discussions of the four blood groups, the history of blood transfusion, and the techniques and results of transfusions are given. The most recent advances in regard to knowledge of the M and N agglutinogen the subgroups of A and AB, the P and X agglutinogens, and the secretor substances are considered. Substantial additions are included in the discussion of the racial distributions of the blood reactions. The genetics of the various blood reactions is thoroughly presented. This new edition should be cordially welcomed by physicians, students of human heredity and physical anthropologists.

—*D. C. Rife.*

Blood Groups and Transfusion, by Alexander S. Weiner. pp. 438. Charles C. Thomas, Springfield, Ill. 1943. $7.50.

STUDIES OF THE GENUS EMPOASCA (HOMOPTERA, CICADELLIDAE)

Part X.[1] Fourteen New Species of Empoasca from Mexico

RALPH H. DAVIDSON and DWIGHT M. DeLONG
Department of Zoology and Entomology,
Ohio State University

This paper is a continuation of our study of the leafhoppers in the genus *Empoasca*. It deals entirely with species taken in Mexico. Species previously described by us from Mexico are as follows: *serrula, dampfi, arator, prona, resupina, duodens, ingena, obstipa, crocostigmata, crocovittata,* and *omani* variety *iguala.*

Empoasca caraba n. sp.

Resembling *madra* somewhat in shape of lateral processes but with extra processes on aedeagus and a distinctly different dorsal spine. Length 3.5 mm.

External characters.—Frons, clypeus, vertex, pronotum and scutellum yellowish. Vertex slightly produced with a median stripe of white which extends across both the pronotum and scutellum. A white spot on each side of median line of vertex. Whitish spots on each side of median line of pronotum. Wings subhyaline with faint golden stripes, apices smoky. Female last ventral segment rounded with a slight median notch.

Internal male genitalia.—Lateral processes heavy, broad at base, tapering gradually caudad to pointed tips that are directed slightly dorsad and gently curved outward. Aedeagus broadened medially with a sharp-pointed apical portion that is directed caudad and dorsad. A pair of long, straight, slender, pointed, processes arise at base of enlarged portion which are directed caudad and dorsad, ending just before apex of aedeagus. The anterior projecting processes connect to the base of the dorsal spine which is broad, directed ventrad, but narrowed abruptly to a pointed slightly anteriorly directed tip.

Holotype male, allotype female, and a large series of male and female paratypes from Carapan, Mich., Mexico, (432 Km.[2]) 10–2–41, collected by DeLong, Good, Plummer, and Caldwell. Also male and female paratypes from Mexico City, Mex. (west 18 Km.) 9–1–39, collected by DeLong; Toluca Road, Mexico, 11–24–38, collected by Caldwell; Tres Cumbres, D. F. (52 Km.) 10–21–41, collected by DeLong, Caldwell, Good and Plummer; Zitacuaro, Mich., (160 Km.) 9–29–41, and Tuxpan, Mich., (185 Km.) 10–5–41, collected by the same men. Types deposited in the authors' collections.

Empoasca stalsisa n. sp.

A small species that appears to be in the *alboneura* group. The lateral processes and dorsal spine are characteristically shaped. Length 3 mm.

External characters.—Color orange-red with smoky spots on the forewings. Vertex slightly produced with a median whitish longitudinal stripe which continues faintly across the pronotum and a white spot on each side next to the eyes. In some specimens, there is another faint whitish spot back of each of those next to the eyes. Pronotum with a median and two lateral whitish spots on anterior margin. Wings hyaline with smoky spots. Female unknown.

Internal male genitalia.—Lateral processes broad basally, narrowed, than gradually broadened, directed caudad and dorsad to pointed tips. In ventral view they are very broad just

[1]Previous parts of this study have appeared as follows: Ohio Journal of Science, 32: 393–401; 35: 29–39; 36: 225–230; 38: 90–96; 39: 110–118; 42: 123–126; and Annals of the Entomological Society, 27: 604–609; 33: 608–611; 35: 105–109.

[2]Distance from Mexico City in kilometers.

before the apex. Aedeagus at apex appearing hour-glass shaped in ventral view. Near base of enlarged portion are anteriorly projecting pieces which connect to the base of the broad, curved, gently rounded dorsal spine.

Holotype male, and a series of male paratypes from Iguala, Guerrero, Mexico, 9–11–39, collected by Dr. DeLong and a male paratype from Santa Engracia, Mexico, 11–8–38, collected by Dr. J. S. Caldwell. Types deposited in the authors' collections.

Empoasca semanta n. sp.

A small species with characteristic internal male genitalia and dorsal spine. Length 2.5 mm.

External characters.—General coloration orange-yellow to light brown. Vertex rounded with a median and two lateral ivory spots. Three ivory spots near anterior margin of pronotum. Forewings tinged dark golden with smoky apices. Hindwings hyaline. Female unknown.

Internal male genitalia.—Lateral processes tapering gently, curving upward to pointed tips which are directed posteriorly and curved slightly outwardly. Aedeagus becoming broadened medially, with a long dorsally directed slightly curved apex and an anteriorly directed portion which is connected to the dorsal spine. Dorsal spine broad at base tapering quickly to a narrow, ventrally and anteriorly directed apex.

Holotype male, and 19 male paratypes from Iguala, Guerrero, Mexico, 9–11–39, collected by the junior author. Types deposited in the authors' collections.

Empoasca cerata n. sp.

Resembling *ingena* in coloration but with long lateral processes similar to *curvata*. Length 3.5 mm.

External characters.—General coloration pale to white marked with reddish to brownish spots. Vertex roundedly produced, with a median black longitudinal line, reddish centrally and lighter near the eyes. Ivory spots surrounding ocelli and a small comma-shaped spot on each side of median black line. Pronotum dark reddish brown with a whitish triangular spot back of each eye. Scutellum dark reddish-brown. Wings sub-hyaline with forewings spotted reddish-brown. Female unknown.

Internal male genitalia.—Lateral processes tapering gradually posteriorly to pointed tips which are directed upward and curve outward. Upper fourth of aedeagus enlarged with a posteriorly directed spine near base of enlargement and an anterior projection connecting to the base of the dorsal spine. Dorsal spine narrowed, directed downward to an anteriorly pointed tip.

Holotype male, and male paratype from Carapan, Mich., Mexico, (432 Km.) 10–2–41, collected by DeLong, Plummer, Good, and Caldwell. Types in the authors' collections.

Empoasca caldwelli n. sp.

A large species with distinct characters of the male genital chamber but resembling those of *thela* and *dilitara*. Length 4 mm.

External characters.—General coloration yellowish. Vertex rounded, with a median and two lateral ivory spots. Pronotum with four irregular ivory spots on anterior margin. Scutellum with two median longitudinal ivory stripes. Wings hyaline with forewings slightly tinged with yellow. Female last ventral segment truncate.

Internal male genitalia.—Lateral processes narrowed at basal half, becoming broader, directed posteriorly and curving upward to pointed tips which appear claw-like. Aedeagus broadened near upper portion with a long anteriorly curving apex and an anteriorly projecting basal portion connecting to the dorsal spine. A long narrow caudal process parallels the upper portion of the aedeagus and arises at base of broadened portion. Dorsal spine lobe-like, directed ventrally with a rounded blunt apex.

Holotype male, allotype female, and a male paratype from Mexico City, Mexico, collected by Dr. A. Dampf on 10–18–32, 10–27–31, and 8–5–32 respectively. Types deposited in the authors' collections.

The authors take pleasure in naming this species after Dr. J. S. Caldwell who has collected and described many species of Homoptera.

Empoasca bispinata n. sp.

Resembling *bifurcata* and other species of the *fabae* group, but with characteristic spines on the aedeagus. Length 3 mm.

External characters.—General coloration golden to pale yellow. Vertex with ivory spotting and a very narrow, median, dark, longitudinal line. Pronotum with three ivory spots on anterior margin; scutellum with median, longitudinal ivory striping and an ivory spot on each anterior corner. Forewings subhyaline with a faint yellowish tinge. Female last ventral segment rounded and slightly produced.

Internal male genitalia.—Lateral processes small, narrow, tapering gradually and curving caudally and slightly dorsally to pointed tips. Aedeagus narrow with a dorsally directed apex and a pair of medially located divergent sharp spines which are directed caudad. Dorsal spine notched at the apex forming two pointed tips, which are directed slightly anteriorly, the ventral one being the longest.

Holotype male and allotype female from Finca Vergel, Chiapas, Mexico, collected by Dr. A. Dampf on 5–22–35 and 5–19–35 respectively. Types deposited in the authors' collections.

Empoasca acantha n. sp.

A spotted species with characteristic shape of lateral processes and dorsal spine. Length 3 mm.

External characters.—Frons and clypeus brown with a median white stripe which continues over the vertex to the pronotum. A white dot on each side of median line of vertex and a white stripe next to each eye. Pronotum brown with a white median spot and two lateral white spots on anterior margin. Wings brown with subhyaline spots and smoky apices. Female last ventral segment roundedly produced.

Internal male genitalia.—Lateral processes, in lateral view broad at base, and bending rather abruptly at two points to form upward pointing tips. Aedeagus narrow, apical fourth slightly enlarged with caudal portion rounded and pointed upward and an anteriorly produced piece which connects to the dorsal spine. Dorsal spine broad at base, gradually tapering to a pointed apex which is directed ventrally and slightly anteriorly.

Holotype male from Acapulco Road, Mexico, 11–22–38, collected by Dr. J. S. Caldwell. Female allotype and a male paratype from Tres Cumbres, D. F. Mexico, (52 Km.) 10–21–41, collected by DeLong, Caldwell, Plummer and Good. Types deposited in the authors' collections.

Empoasca rumexa n. sp.

Resembling *sativae* externally but with characteristic shape of lateral processes and heavy dorsal spine as in *delongi*. Length 2.5 mm.

External characters.—Color golden yellow with white spots. Vertex slightly produced with a median and two oblique white spots on the dorsal side. Pronotum with a median broadly wedge-shaped white spot and lateral white spots on anterior margin. Scutellum with a median longitudinal white stripe. Wings hyaline with the first pair slightly tinged with yellow. Female unknown.

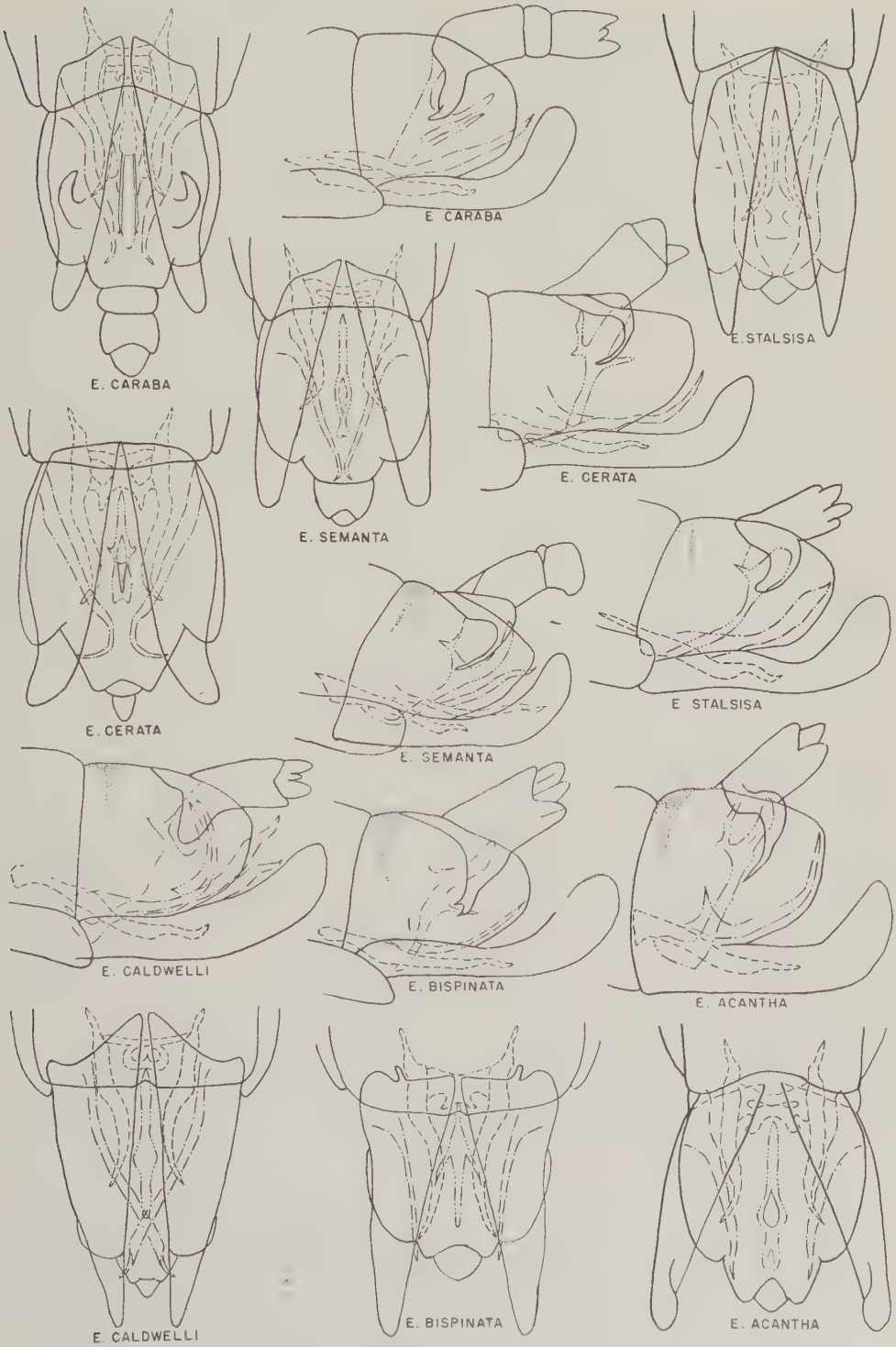
Internal male genitalia.—Lateral processes gradually tapered, curving upward to pointed tips which are bent inward. Aedeagus enlarged and rounded at apex with anterior processes arising at base of enlargement and connecting to the base of the dorsal spine. Dorsal spine heavy and long, tapered to a pointed tip directed ventrally and slightly anteriorly.

Holotype male, and male paratypes from Iguala, Guerrero, Mexico, 9–11–39, collected by the junior author and deposited in the authors' collections.

Empoasca adexa n. sp.

A small spotted species resembling *acantha* in coloration but with distinctly different lateral processes and dorsal spine. Length 2.5 mm.

External characters.—Frons and clypeus brown with a median white stripe which continues over the vertex to the pronotum. On each side of the median line on margin of the vertex is a



Ventral and lateral views of the posterior end of the abdomen showing the internal pieces of the male genital chamber.

white dot and a dash of white next to each eye. Dorsally the vertex has a white spot on each side of posterior margin next to the eyes. Pronotum brown with a median gray longitudinal stripe, a white spot behind each eye and a thin median white spot on anterior margin. Wings brown with subhyaline spots. Female last ventral segment rounded and produced medially.

Internal male genitalia.—Lateral processes small, tapered gradually, curving caudally and dorsally with the rather pointed tips directed inwardly. Aedeagus narrow with apical third enlarged, rounded and directed dorsally with an anterior dorsally produced piece near base of enlargement which connects to the dorsal spine. Dorsal spine broad at base tapering gradually and curving ventrally and anteriorly to a bifid apex, which is curved slightly inward.

Holotype male, allotype female and male and female paratypes from Carapan, Mich., Mexico (432 Km.) 10–2–41, collected by DeLong, Good, Caldwell and Plummer. A male paratype from Acapulco Road, Mexico, 11–22–38, collected by Dr. J. S. Caldwell. Types deposited in the authors' collections.

Empoasca serpula n. sp.

A small species resembling *galluxa* in shape of lateral processes, but with a very long curved dorsal spine by which the separation can be easily made. Length 2.5 mm.

External characters.—Frons, clypeus, vertex, pronotum and scutellum yellow to golden. Vertex slightly produced with a faint median line and a dash of white on each side. Pronotum with two median and two lateral white spots on anterior margin. Wings subhyaline. Female last ventral segment truncate.

Internal male genitalia.—Lateral processes short, slender, about same length as the styles, gently curving dorsad to inwardly curved tips. Aedeagus near apex long, narrow and dorsally directed, with anteriorly projecting pieces which connect to the base of the long narrow curving dorsal spine that almost parallels the pygofers. The tips of the spine are gently curved inward.

Holotype male, allotype female, and two male and one female paratypes from Iguala, Guerrero, Mexico, 9–11–39, collected by DeLong; one male paratype from Mexico City, 9–19–31, collected by Dr. A. Dampf. Types deposited in the authors' collections.

Empoasca bulba n. sp.

Resembling *bicorna* in shape of lateral processes but with very broad aedeagus in ventral view and a truncate dorsal spine. Length 3 mm.

External characters.—Vertex roundedly produced, yellowish in color with some greenish areas and a very faint median line. Pronotum and scutellum yellowish-green with a median whitish spot on anterior margin of pronotum. Wings subhyaline with a tinge of yellowish-green. Female last ventral segment roundedly produced.

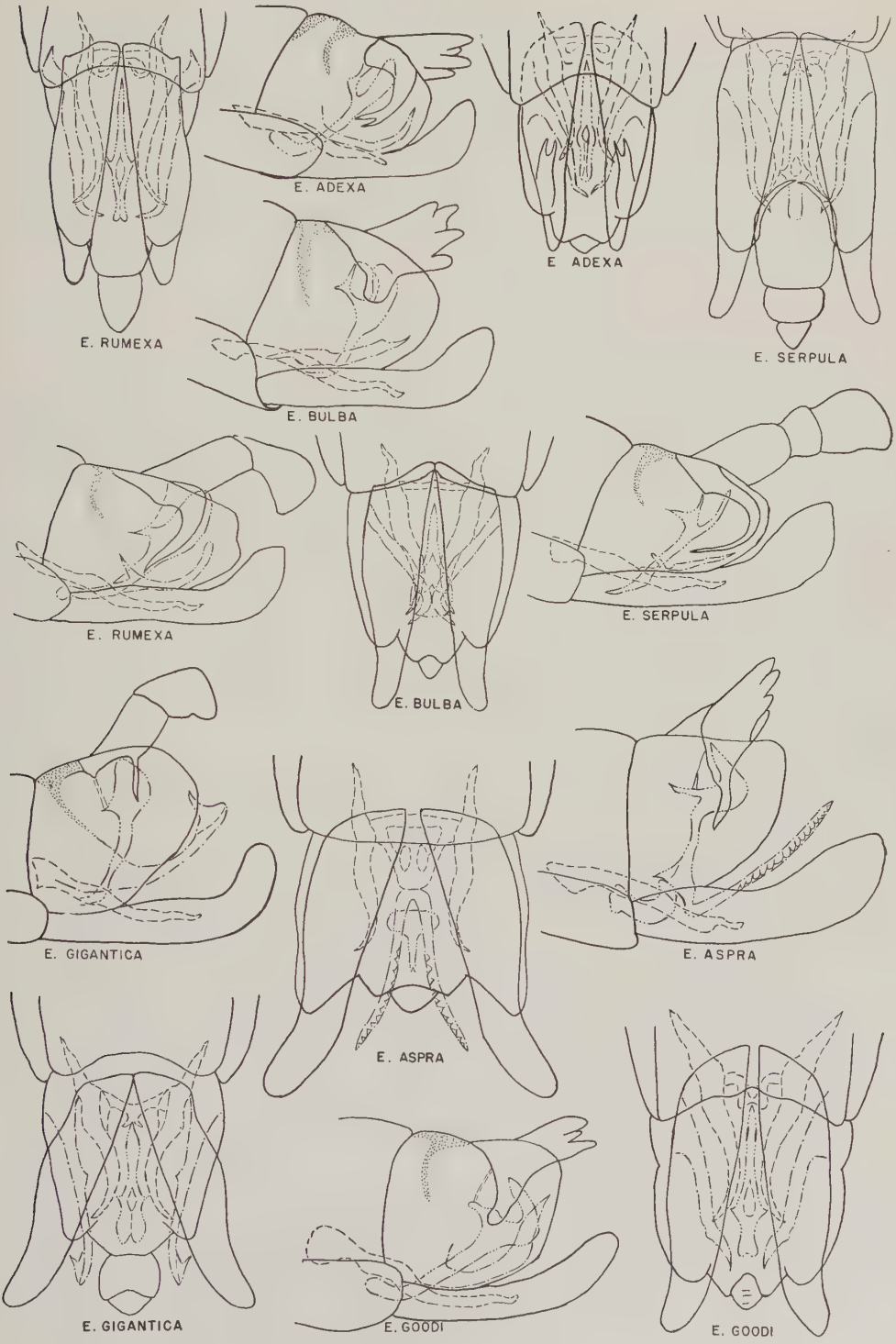
Internal male genitalia.—Lateral processes in ventral view, short, stout, curving inwardly to tapered pointed tips which are bent and directed outward. Aedeagus very broad at apex in ventral view and medially notched. In lateral view the apex is enlarged and rounded with an anterior projecting piece near base of bulbous portion which connects to dorsal spine. Dorsal spine broad at base and narrowed slightly to a truncated ventrally directed apex.

Holotype male, allotype female, and male and female paratypes from Cordoba, V. C. Mexico, 10–8–41, collected by DeLong, Good, Caldwell and Plummer. Also three male paratypes from Carapan, Mich., Mexico, (432 Km.) 10–2–41, collected by the same men and one male paratype from Vera Cruz, Mexico, Aug. 1934, collected by Dr. A. Dampf. Types in the authors' collections.

Empoasca aspra n. sp.

Resembling *ponderosa* in shape of dorsal spine, but a much larger species with heavier processes on the aedeagus. Length 4.5 mm.

External characters.—Frons, clypeus, vertex, pronotum and scutellum yellow-green. Vertex slightly produced with a faint median line. Pronotum with a whitish spot on anterior margin, subhyaline in central area and posterior margin. Wings milky to subhyaline. Female last ventral segment roundedly produced.



Ventral and lateral views of the posterior end of the abdomen showing the internal pieces of the male genital chamber.

Internal male genitalia.—Base of aedeagus with a pair of long processes extending dorsally and caudally. These are much heavier than those found in *ponderosa* but very similar to those of *coccinea*. Apical portion in side view, with a broad posteriorly directed piece that curves sharply and tapers abruptly to a dorsally pointed tip. Upper part of aedeagus attached to the base of the dorsal spine which is ventrally directed and dagger-shaped except for a shallow notch on the anterior margin. Bending at the notch causes the tip to curve slightly anteriorly.

Holotype male, allotype female, and a large series of male and female paratypes from Rio Frio, D. F. Mexico, (55 Km.) collected by DeLong, Good, Plummer, and Caldwell on 10–7–41, and a pair of paratypes from Acapulco Road, Mexico, 11–22–38, collected by J. S. Caldwell. Types deposited in the authors' collections.

Empoasca gigantica n. sp.

A very large species which resembles *dactylata* in shape of lateral processes but with characteristic dorsal spine and coloration. Length 5–5.5 mm.

External characters.—Coloration somewhat variable in degree and intensity, the males showing the deeper tones. Frons and clypeus of males usually black which extends to margin of vertex. From dorsal aspect this coloration appears as three black spots, one median and two lateral next each eye. Remainder of vertex greenish-yellow with a faint black median line and a green spot on each side. Pronotum greenish-yellow anteriorly, becoming darker centrally and posteriorly. Three darkened stripes often present on scutellum. Wings milky to hyaline with brown spotting. Females have similar coloration except for yellow frons and clypeus and three black dots on margin of vertex. Female last ventral segment roundedly produced.

Internal male genitalia.—Lateral processes in lateral view, long, curved slightly upward, with a dorsally projecting process just before the rounded apex. Aedeagus much broadened apically in lateral view. Dorsal spine quite small and narrowed to a ventrally projecting tip.

Holotype male, allotype female, and a large series of male and female paratypes from Rio Frio, D. F. Mexico (55 Km.) collected by DeLong, Good, Caldwell, and Plummer on 10–7–41, and Mt. Popo, Mexico, 9–28–41, collected by the same men. Types deposited in the authors' collections.

Empoasca goodi n. sp.

A large species, resembling *gigantica* in size and coloration, but with distinctly different dorsal spine and lateral processes. Length 5 mm.

External characters.—Frons and clypeus of males usually brown to black colored. This extends to the margin of the vertex which appears from dorsal view as three black dots, one median and two lateral, which are next to the eyes. Remainder of the vertex greenish-yellow with a very faint median line. Pronotum yellowish anteriorly, becoming darker centrally and posteriorly. Scutellum yellow in color. Wings hyaline with faint yellow striping and smoky apices. Females similar in color except for yellow frons and clypeus and three black dots on margin of vertex. Female last ventral segment almost truncate with a median notch.

Internal male genitalia.—In lateral view, the lateral processes are directed posteriorly for one half their length, becoming broadened at this point and bending upward and tapering to pointed tips. Aedeagus in lateral view, enlarged near the apex into a hook-like process which is directed upward and slightly anteriorly. Dorsal spine broad at base and gradually narrowed to a rounded apex which is directed ventrad.

Holotype male, allotype female, and a large series of male and female paratypes from Carapan, Mich., Mexico (432 Km.) 10–2–41, all collected by Drs. D. M. DeLong, J. S. Caldwell, C. C. Plummer and Mr. E. E. Good. Other paratypes from Mexico City, D. F. 9–13–39, collected by DeLong; and Rio Frio, D. F. Mexico, 10–7–41, collected by the above named men. Types deposited in the authors' collections.

The authors take pleasure in naming this species after Mr. E. E. Good who has collected many interesting species of Cicadellidae.

PROTOZOAN PARASITES OF THE ORTHOPTERA, WITH SPECIAL REFERENCE TO THOSE OF OHIO

IV.[1] Classified List of the Protozoan Parasites of the Orthoptera of the World. Classes Mastigophora, Sarcodina, and Sporozoa

FRANK MERRICK SEMANS
The Ohio State University
and
Youngstown College

This classified list of all protozoan parasites thus far reported for Orthoptera has been assembled for the purpose of making available from one source much information which formerly has been obtainable only by consulting and comparing a large number of books and papers.[2]

Beginning with class, and continuing down through genus, a short, characterizing description is given for each group. That these descriptions are mutually exclusive will be seen by comparing two groups of the same level, i.e., two classes, two orders, etc.

Under species, certain symbols have been used to relate the data under the various headings. Each reference is numbered and this is the number which is used to refer to that author under the other headings for that species. For example, a synonym followed by (1) indicates that author number (1), above, used that name for the parasite. Further, each host is indicated by a letter and followed by one or more numbers. The numbers, of course, again refer to the authors who studied that host, and the letter is used to refer to the host in the following data. For example, under *Leptomonas blaberae*, the first parasite listed, we find under distribution "Catuche, Venezuela" followed by "(la)." This means that author (1) above (Tejera) found *L. blaberae* in host "a" (*Blabera* sp.) captured in Catuche, Venezuela. Where more authors, etc., are listed, the method is the same, the number always referring to the author and the letter to the host.

In the lists of references, only works of a monographic nature are cited. This excludes most texts and general works, unless they contain original work in addition to mere compilation. In every case, only the first page of a reference is given, unless it is discontinuous, in which case the separate pages are given.

In the host lists, only the accepted names are used.

For habitat, i.e., the region of the insect in which the parasite was found, only the accepted terminology is used. (References: Comstock, 1930; Imms, 1929.)

Frequently, some localities are omitted under the heading "distribution." This means that the author did not specifically state where his material was collected and where he did his work.

---

[1]Part I: Ohio Jour. Sci., 36: 315–320. 1936. Part II: Ohio Jour. Sci., 39: 157–181. 1939. Part III: Ohio Jour. Sci., 41: 457–464. 1941.

[2]A bibliography will be included in a continued paper to appear in the next issue of this Journal.

CLASSIFIED LIST

Class 1. MASTIGOPHORA Diesing, 1865.

Possess one or more flagella during the greater part of the life-history, and in the adult state always.

Order 1. PROTOMONADIDA Blochmann, 1895.

Possess few flagella (rarely more than 6), one nucleus, and are usually without accessory internal organs.

Family 1. *Trypanosomidae* Doflein, 1901.

Possess a single flagellum, and are parasitic in vertebrates, invertebrates, or plants.

Genus 1. **Leptomonas** Kent, 1880. Found only in invertebrate hosts, and never developing beyond the *Leptomonas* stage, showing only this and *Leishmania* forms in their life cycle.

Leptomonas blaberae Tejera, 1926.
References: (1) Tejera, 1926, 1382.
Synonymy: Name unchanged.
Hosts: (a) *Blabera* sp.
Habitat: ?
Distribution: Catuche, Venezuela (1a).

Leptomonas sp.
References: (1) This paper, parts II and III.
Hosts: (a) *Parcoblatta virginica* (Brunner); (b) *P. lata* (Brunner); (c) *P. pensylvanica* (DeGeer); all by (1).
Habitat: Hind-intestine, (1a), (1b), (1c).
Distribution: Franklin (1a), (1c); Fairfield (1b), (1c); Champaign (1c); Hocking (1b); Logan (1c); Madison (1c); and Washington (1c) Counties Ohio.

Genus 2. **Herpetomonas** Kent, 1880. Found only in invertebrate hosts, but showing *Leishmania*, *Leptomonas*, *Crithidia*, and *Trypanosoma* types in their cycles.

Herpetomonas periplanetae Laveran and Franchini, 1920.
References: (1) Laveran and Franchini, 1920a, 145; (2) Laveran and Franchini, 1920b, 331.
Synonymy: Name unchanged.
Hosts: (a) *Blatta orientalis* Linnaeus, (1), (2).
Habitat: Alimentary canal, (1a), (2a).
Distribution: Paris, France, (2a); Bologna, Italy, (1a).

Family 2. *Cryptobiidae* Poche, 1913.

Possess two flagella, one of which is directed forward, while the other passes backward and is attached to the surface of the body, and may be raised into an undulating membrane.

Genus 1. **Cryptobia** Leidy, 1846. Found in intestinal canal of fishes and seminal vesicles and spermatophores of molluscs and other invertebrates.

Cryptobia gryllotalpae (Hamburger, 1911).
References: (1) Hamburger, 1912, 216; (2) This paper, under synonymy.
Synonymy: *Trypanoplasma gryllotalpae* (1); *Cryptobia gryllotalpae* (2). (Genus *Cryptobia* Leidy substituted for *Trypanoplasma* Laveran and Mesnil. See Kudo, 1931, 147.)
Hosts (a) *Gryllotalpa gryllotalpa* Linnaeus (1).
Habitat: Hind-intestine, (1a).
Distribution: Heidelberg, Germany, (1a).

Family 3. *Bodonidae* Doflein, 1901.

Possess two flagella, one of which is directed backward as a trailing flagellum.

Genus 1. **Embadomonas** Mackinnon, 1911. Found in the intestine of mammals and insects.

Embadomonas blattae Bishop, 1931.
References: (1) Bishop, 1931, 287.
Synonymy: Name unchanged.
Hosts: (a) *Blatta orientalis* Linnaeus, (1).
Habitat: Hind-intestine, (1a).
Distribution: Cambridge, England, (1a).

Order 2. Polymastigida Blochmann, 1884.

Possess three to eight flagella, one to many nuclei, and frequently axostyle or axial filament.

Tribe 1. *Monozoa* Calkins, 1926.

Possess one cytostome and kinetic element.

Genus 1. **Retortamonas** Grassi, 1879. Possess four flagella, one of which trails. Parasitic in the intestine of various insects.

Retortamonas gryllotalpae Grassi, 1879.

References: (1) Grassi, 1879, 448; (2) Grassi, 1881, 153, 161, et. al.; (3) Hamburger, 1912, 216.

Synonymy: *Retortamonas gri* (and *y*) *llotalpae*, (1), (2); *Schedoacercomonas melolonthae*, (1); *S. gri* (and *y*) *llotalpae*, (1); *Monocercomonas insectorum*, (2), (3); *Plagiomonas Gri* (and *y*) *llotalpae*, (2).

Hosts: (a) Larval gryllotalpae, (2).

Habitat: Hind-intestine, (2a).

Distribution: Rovellasca, Italy (?), (2a).

Retortamonas orthopterorum (Parisi, 1910) Wenyon, 1926.

References: (1) Parisi, 1910, 235; (2) Hamburger, 1912, 216; (3) Belar, 1916, 243; (4) Wenyon, 1926, 678; (5) Kudo, 1931, 159; (6) McAdow, 1931, 21; (7) Balch, 1932, 237.

Synonymy: *Trichomonas orthopterorum*, (1), (2); *Monocercomonas orthopterorum*, (3), (7); *Retortamonas orthopterorum*, (4), (5), (6).

Hosts: (a) *Ectobia lapponica* (Linnaeus), (1); (b) *Blatta orientalis* Linnaeus (1); (c) *Gryllotalpa gryllotalpa* Linnaeus, (1), (2). Also reported as *Monocercomonas orthopterorum* from *Tipula abdominalis*, a dipteran. (See Geiman, 1932, 173).

Habitat: Alimentary canal, (1c), (1a); Hind-intestine, (1a), (1b), (1c); rectum, (2c).

Distribution: Heidelberg, Germany, (2c); Lombardy, Italy, (1a), (1b), (1c); Trentino, Italy, (1b); Baden, (?), (1b).

Tribe 2. *Diplozoa* Calkins, 1926.

Possess two cytostomes and kinetic elements.

Genus 1. **Octomitus** Prowazek, 1904. Possess six anterior and two posterior flagella. Parasitic.

Octomitus periplanetae Belar, 1916.

References: (1) Belar, 1916, 254; (2) Kudo, 1931, 162; (3) McAdow, 1931, 21.

Synonymy: Name unchanged.

Hosts: (a) "Kitchen-cockroach," (1).

Habitat: Alimentary canal, (1a).

Distribution: Vienna, Austria, (1a).

Order 3. Hypermastigida Grassi, 1911.

Possess numerous flagella, a single nucleus, and may have axostyles and parabasal bodies.

Family 1. *Lophomonadidae* Grassi, 1885.

Flagella arise from the anterior end in a tuft. Parasitic in cockroaches and termites.

Genus 1. **Lophomonas** Stein, 1860. Parasitic in the colon of cockroaches.

Lophomonas blattarum Stein, 1860.

References: (1) Stein, 1860, 49; (2) Bütschli, 1878, 258; (3) Leidy, 1879, 204; (4) Kent, 1880–1882, 321; (5) Grassi, 1881, 172; (6) Schuster, 1898, 242; (7) Janicki, 1908, 141; (8) Janicki, 1910, 244; (9) Belar, 1916, 242; (10) Kudo, 1922, 113; (11) Kudo, 1926a, 191; (12) Kudo, 1926c, 504; (13) McAdow, 1931, 15.

Synonymy: *Lophomonas Blattarum*, (1), (5); *Lophomonas blattarum*, (2), (3), (4), (6), (7), (8), (9), (10), (11), (12), (13).

Hosts: (a) *Blatta orientalis* Linnaeus, (1), (2), (7), (8), (10), (11), (12); (b) *Blatta* sp. (5); (c) *Periplaneta americana* (Linnaeus), (6); (d) *Gryllotalpa* sp., (8).

Habitat: Hind-intestine, (2a), (7a), (8a), (8d); colon, (6c), (13?); rectum, (1a), (13?).

Distribution: Europe, (8a), (8d); Germany, (2a); Rome, Italy, (7a); Rovellasca, Italy ?, (5b); Urbana, Illinois, (10a), (11a), (12a); Ohio, (13?).

Lophomonas striata Bütschli, 1878.

References: (1) Bütschli, 1878, 258; (2) Kent, 1880–1882, 322; (3) Grassi, 1881, 177; (4) Schuster, 1898, 243; (5) Janicki, 1908, 144; (6) Janicki, 1910, 244; (7) Belar, 1916, 242; (8) Kudo, 1922, 113; (9) Yakimoff and Miller, 1922a, 9; (10) Yakimoff and Miller, 1922b, 133; (11) Kudo, 1926c, 504; (12) Tejera, 1926, 1382; (13) Lucas, 1928, 172; (14) Weill, 1929, 22; (15) McAdow, 1931, 15.

Synonymy: *Lophomonas striata*, (1), (2), (5), (6), (7), (8), (9), (10), (11), (12), (13), (14), (15); *Lophomonas Striata*, (3); *Lophomonas sulcata*, (4). (*L. sulcata* was distinguished by Schuster from *L. striata* chiefly on the basis of the greater size of the former. Kudo (1926c, 505) intimates that the size and characteristics described for *L. sulcata* are comprehended by those of *L. striata*.)

Hosts: (a) *Blatta orientalis* Linnaeus, (1), (5), (6), (8), (11); (b) *Periplaneta americana* (Linnaeus), (4), (14); (c) *Gryllotalpa* sp., (6).

Habitat: Alimentary canal, (4b), (13?); hind-intestine, (1a), (5a), (6a), (6c), (14b); colon and rectum, (15?).

Distribution: Europe, (6a), (6c); Germany, (1a); Rome, Italy, (5a); French Indo-China, (14b); Urbana, Illinois, (8a), (11a); Ohio, (15?).

Class 2. SARCODINA Hertwig and Lesser, 1874.

Capable of changing the body form and forming pseudopodia, both for locomotion and food-capturing.

Order 1. Amoebida Calkins, 1902.

Body unprotected by any shell or skeletal structure. Cytoplasm differentiated into endo- and ectoplasm.

Family 1. *Endamoebidae* Calkins, 1926.

Endoparasitic, with wide zoological distribution.

Genus 1. **Endamoeba** Leidy, 1879. Nucleus spherical or oblong with very thick membrane. Several endosomes. Parasitic in invertebrates.

Endamoeba blattae (Bütschli, 1878) Leidy, 1879.

References: (1) Bütschli, 1878, 273; (2) Leidy, 1879, 204; (3) Grassi, 1881, 184; (4) Schubotz, 1905, 6; (5) Mercier, 1907, 1132; (6) Janicki, 1908, 148; (7) Mercier, 1908b, 943; (8) Elmassian, 1909, 144; (9) Janicki, 1909, 381; (10) Mercier, 1909, 164; (11) Mercier, 1910, 143; (12) Belar, 1916, 242; (13) Kudo, 1922, 113; (14) Yakimoff and Miller, 1922b, 133; (15) Kudo, 1926b, 139; (16) Kudo, 1926c, 505; (17) Thompson and Lucas, 1926, 41; (18) Lucas, 1927a, 220; (19) Lucas, 1928, 161 and 171; (20) McAdow, 1931, 13; (21) Balch, 1932, 237.

Synonymy: *Amoeba blattae*, (1), (2), (4), (5), (6), (7), (8), (10); *Endamoeba blattae*, (2), (13), (15), (16), (17), (18), (19), (20), (21); *Amoeba Blattae*, (3); *Entamoeba blattae*, (9), (11), (12), (14). Yakimoff and Miller (1922a) and Tejera (1926) mention an *Entamoeba battarum* in "*Periplaneta orientalis*" and "Blattes," respectively; later corrected by Yakimoff (1922b) and changed to *Entamoeba blattae*. For the same hosts, they give a *Monas* sp. (origin?), Yakimoff and Miller including *Lophomonas blattae* (doubtless *L. blattarum* Stein, 1860) and *Oicomonas* sp. (origin?), and Tejera includes *Oikomonas blattarum* (origin?) and *Plagiostoma blattarum* (undoubtedly *Plagiotoma blattarum* Stein, 1859, now *Nyctotherus ovalis* Leidy, 1850.)

Hosts: (a) *Blatta orientalis* Linnaeus, (1), (4), (5), (6), (9), (10), (11), (13), (15), (17), (19), (20); (b) *Periplaneta americana* (Linnaeus), (19).

Habitat: Alimentary canal, (10a); hind-intestine, (1a), (4a), (5a), (6a), (9a), (11a), (17a); colon, (15a), (20a); rectum, (20a).

Distribution: London, England, (19a); France, (5a), (10a), (11a); Germany, (1a), (4a); Rome, Italy, (6a), (9a); Rovellasca, Italy (?), (3?); Urbana, Illinois, (13a), Baltimore, Maryland, (19b); Ohio, (20a).

Endamoeba thomsoni Lucas, 1927.

References: (1) Lucas, 1927b, 224; (2) Lucas, 1928, 173; (3) Smith and Barret, 1928, 272; (4) Taliaferro, 1928, 274; (5) McAdow, 1931, 14; (6) Balch, 1932, 237.

Synonymy: *Entamoeba thomsoni*, (1), (2), (4), (5); *Endamoeba thomsoni*, (3), (6).

Hosts: (a) *Blattella germanica* (Linnaeus), (5); (b) *Blatta orientalis* Linnaeus, (5); (c) *Periplaneta americana* (Linnaeus), (1), (3), (5).

Habitat: Hind-intestine, (3c); colon and rectum, (5a), (5b), (5c).

Distribution: England, (1c); Charlotte, North Carolina, (3c); Ohio, (5a), (5b), (5c).

Genus 2. **Entamoeba** Casagrandi and Barbagallo, 1895. Nucleus vesicular, membrane thin but distinct. Small endosome. Numerous species in man, mammals and invertebrates.

Entamoeba nana Tejera, 1926.

References: (1) Tejera, 1926, 1382.

Synonymy: Name unchanged.

Hosts: (a) *Blaberus atropos* (Stoll), (1).

Habitat: Alimentary canal, (1a).

Distribution: Venezuela, (1a).

Genus 3. **Endolimax** Kuenen and Swellengrebel, 1917. Nucleus with definite membrane; large, irregular endosome. Small parasitic amoebae.

Endolimax blattae Lucas, 1927.

References: (1) Lucas, 1927a, 220; (2) Lucas, 1927b, 229; (3) Weill, 1929, 23; (4) McAdow, 1931, 21.

Synonymy: Name unchanged.

Hosts: (a) *Blatta orientalis* Linnaeus, (2); (b) *Periplaneta americana* (Linnaeus), (2), (3).

Habitat: Hind-intestine, (2a), (2b); rectum, (3b).

Distribution: England, (2a), (2b); French Indo-China, (3b).

Class 3. SPOROZOA Leuckart, 1879.

Possess no cilia or flagella. Occasionally move about by pseudopodia when immature, but nutrition is by absorption only. Usually non-motile and reproducing by spores.

Subclass 1. Telosporidia Schaudinn, 1900.

Spores have neither polar capsule nor polar filament. Spore formed at the end of the trophic life and contains one to several sporozoites.

Order 1. Gregarinida Bütschli, 1882.

Coelozoic parasites in invertebrates. The vast majority do not undergo schizogony.

Tribe 1. *Acephalinidea* Kölliker, 1848.

Body an unsegmented mass of cytoplasm.

Family 1. *Diplocystidae* Bhatia, 1930.

Spores spherical or oval, with eight sporozoites.

Genus 1. **Diplocystis** Kunstler, 1887. (Not Penard, 1890. See Cuénot, 1897b.) Trophozoites fuse precociously to form spherical masses. Coelomic.

Diplocystis schneideri Kunstler, 1887.

References: (1) Kunstler, 1887, 25; (2) Léger, 1892, 45; (3) Labbé, 1899, 46; (4) Magalhães, 1900, 44; (5) Cuénot, 1901, 598; (6) Léger and Duboscq, 1902b, 384; (7) Lühe, 1904, 113, 139; (8) Woodcock, 1904, 127; (9) Schiffman, 1919, 81; (10) Jameson, 1920, 207; (11) Bhatia, 1930, 161.

Synonymy: *Diplocystis schneideri*, (1), (3), (4), (5), (7), (9), (10), (11); *Diplocystis Schneideri*, (2), (6), (8).

Hosts: (a) *Blatta orientalis* Linnaeus, (8), (10); (b) *Periplaneta americana* (Linnaeus), (1), (10).

Habitat: Coelom, (1b), (10a), (10b); posterior mid-intestinal wall, (10a), (10b).

Distribution: London, England, (10a), (10b); France, (1b).

Diplocystis major Cuénot, 1897.

References: (1) Cuénot, 1894, 806; (2) Cuénot, 1895, 321; (3) Cuénot, 1897a, 54; (4) Labbé 1899, 46; (5) Léger and Duboscq, 1900, 1567; (6) Caullery and Mesnil, 1901, 84; (7) Cuénot, 1901, 595; (8) Léger and Duboscq, 1901, 439; (9) Léger and Duboscq, 1902a, 41; (10) Léger and Duboscq, 1902b, 384, 452; (11) Lühe, 1904, 93, 96, 113, 139, 161; (12) Woodcock, 1904, 127; (13) Dogiel, 1909, 201, 206; (14) Wellmer, 1910, 532; (15) Wellmer, 1911, 144.

Synonymy: *Diplocystis* sp., (1); *Diplocystis major*, (2), (3), (4), (5), (6), (7), (8), (9), (10,) (11), (12), (13), (14), (15).

Hosts: (a) *Gryllus domesticus* Linnaeus, (1), (2), (3), (7), (9), (14), (15).

Habitat: Coelom, (1a), (2a), (3a), (7a), (9a), (15a), (8?).

Distribution: East Prussia, (14a), (15a); Altkirch and Roscoff, France, (7a); Ardennes, France, (2a), (3a); Haute-Loire, France, (7a); Joinville and Nancy, France, (3a), (7a).

Diplocystis minor Cuénot, 1897.

References: (1) Cuénot, 1897a, 54; (2) Labbé, 1899, 46; (3) Cuénot, 1901, 595; (4) Léger and Duboscq, 1902b, 385; (5) Lühe, 1904, 113; (6) Woodcock, 1904, 127; (7) Dogiel, 1909, 206.

Synonymy: Name unchanged.

Hosts: (a) *Gryllus domesticus* Linnaeus, (1), (3).

Habitat: Coelom, (1a), (3a).

Distribution: Beauvais and Chauny, France, (1a), (3a); Sauville, Villerle-Tilleul, Vendresse, and Nancy, France, (3a).

Tribe 2. *Cephalinidea* Delage, 1896.

Body divided into two portions by a septum of the ectoplasm.

Family 1. *Gregarinidae* Labbé, 1899.

Associative or solitary; satellite with septum. Epimerite symmetrical, simple. (In the opinion of the author, the mere observation of cyst development and dehiscence does not give conclusive evidence as to the identity of an adult found

in the same habitat, unless cyst formation is observed, which is rarely the case. Unless the latter phenomenon has been observed, cyst characters are disregarded in the description of new species of Gregarinidae, and they are classified as far as possible on the basis of adult characteristics, comparing them with previously named species. In order to make possible a more accurate classification of Gregarinidae than now exists, it will be necessary to determine methods of culturing species of gregarines so as to obtain them in large numbers, and to perfect a technique for bringing about cyst formation under observation.)

Genus 1. **Leidyana** Watson, 1915. Solitary. Epimerite a simple, globular, sessile knob. Dehiscence by spore ducts. Spores barrel-shaped, in chains.

Leidyana gryllorum (Cuénot, 1897) Watson, 1916.

References: (1) Cuénot, 1897a, 54; (2) Labbé, 1899, 10; (3) Cuénot, 1901, 594; (4) Watson, 1916a, 120; (5) Bhatia and Setna, 1924, 288; (6) This paper, parts II and III.

Synonymy: *Clepsidrina gryllorum*, (1); *Gregarina macrocephala*, (2); *Gregarina gryllorum*, (3); *Leidyana gryllorum*, (4), (5), (6).

Hosts: (a) *Gryllus assimilis* Fabricius, (6); (b) *Gryllus domesticus* Linnaeus, (1), (2), (3); (c) *Gryllus* spp., (5); (d) *Nemobius sylvestris* (Bosc d'Antic), (2); (e) *Nemobius fasciatus fasciatus* (DeGeer), (6).

Habitat: Alimentary canal, (1b), (2b), (2d); gizzard and mid-intestine, (5c); enteric ceca and mid-intestine, (6e); mid-intestine, (3b), (6a).

Distribution: Ardennes, France, (2b), (2d), (1b), (3b); Nancy, Joinville, and Roscoff, France, (3b); Lahore, India, (5c); Franklin and Washington Counties, Ohio, (6a), (6e).

Leidyana erratica (Crawley, 1907) Watson, 1916.

References: (1) Crawley, 1903a, 45; (2) Crawley, 1903b, 639, 641; (3) Crawley, 1907, 221; (4) Ellis, 1913c, 286; (5) Watson, 1915, 35; (6) Watson, 1916a, 118; (7) Kamm, 1922a, 133; (8) Bhatia and Setna, 1924, 288; (9) This paper, parts II and III.

Synonymy: *Gregarina achetaeabbreviatae*, (1), (2); *Stephanophora erratica*, (3), (4); *Leidyana solitaria*, (5); *Leidyana erratica*, (6), (7), (8), (9).

Hosts: (a) *Gryllus assimilis* Fabricius, (3), (5), (6), (9); (b) *Gryllus* spp., (8); (c) *Nemobius fasciatus fasciatus* (DeGeer), (9); (d) *Nemobius fasciatus socius* Scudder, (9); (e) *Anaxipha exigua* (Say), (9); (f) *Hapithus agitator agitator* Uhler, (9).

Habitat: Alimentary canal, (6a); gizzard, (8b); enteric ceca, (9c), (6a); mid-intestine, (8b), (9a), (9c), (9d), (9e), (9f).

Distribution: Lahore, India, (8b); Beach Haven, New Jersey, (3a); Cold Spring Harbor and Oyster Bay, New York, (6a); Champaign County, Ohio, (9d); Franklin County, Ohio, (9a); Delaware County, Ohio, (9e); Washington County, Ohio, (9a), (9c), (9e), (9f).

Genus 2. **Gregarinoides** Fantham, 1925. Biassociative. Epimerite small, globular, or cylindric. Dehiscence by simple rupture.

Gregarinoides locustanae Fantham, 1925.

References: (1) Fantham, 1923, 495; (2) Fantham, 1924, 438; (3) Fantham, 1925, 351; (4) Bush, 1928, 157, et. al.

Synonymy: Reference, but name not used, (1), (2); *Gregarinoides locustanae*, (3), (4).

Hosts: (a) *Locustana pardalina* (F. Walker), (1), (3); (b) 35 ? species of "Acridiidae" common to Natal, South Africa, (4).

Habitat: Mid-intestine, (1a), (3a).

Distribution: Pietermaritzburg, Natal, (4b); Johannesburg, Transvaal, (1a), (3a).

Genus 3. **Gregarina** Dufour, 1828. (Often incorrectly given as 1826.) Biassociative. Epimerite small, globular or cylindric. Dehiscence by spore ducts. Spores barrel-shaped to cylindric.

This classification is based, in part, on the presence of these gregarines in hosts of common classification, i. e., hosts of the same family, etc. This is justifiable inasmuch as these groups of protozoan parasites from related hosts present certain marked resemblances, whether through adaptation or common ancestry.

Division 1. *Actinocephalus*-like sporonts. Hosts, Gryllidae, etc.

Gregarina hyalocephala Dufour, 1837.

References: (1) Dufour, 1837, 13; (2) Siebold, 1839, 70; (3) Frantzius, 1846; (4) Diesing, 1851, 11; (5) Diesing, 1859, 731; (6) Lankester, 1863, 94; (7) Labbé, 1899, 34; (8) Watson, 1916a, 97, 214.

Synonymy: Name unchanged.

Hosts: (a) *Tridactylus variegatus* (Latreille), (1); (b) *Tridactylus* spp., (1).

Habitat: Mid-intestine, (1a), (1b).

Distribution: France, (1a), (1b).

Gregarina conica Dufour, 1837.
References: (1) Dufour, 1837, 12; (2) Siebold, 1839, 70; (3) Desmarest, 1845, 317; (4) Frantzius, ?; (5) Diesing, 1851, 8; (6) Diesing, 1859, 729; (7) Lankester, 1863, 95; (8) Watson, 1916a, 125.
Synonymy: Name unchanged.
Hosts: (a) Gryllidae, spp., (1).
Habitat: Mid-intestine, (1a).
Distribution: France, (1a).

Gregarina oblonga Dufour, 1837.
References: (1) Dufour, 1837, 13; (2) Frantzius, 1846; (3) Frantzius, 1848, 195; (4) Diesing, 1851, 11; (5) Diesing, 1859, 732; (6) Lankester, 1863, 94; (7) Watson, 1916a, 96.
Synonymy: Name unchanged.
Hosts: (a) *Locusta migratoria* Linnaeus, (1); (b) *Acheta campestris* (Linnaeus), (1).
Habitat: Mid-intestine, (1a), (1b).
Distribution: France, (1a), (1b).

Division 2. Gregarine more or less cylindric.

Subdivision 1. Hosts, Blattidae.

Group 1. Gregarine tenuous.

Gregarina panchlorae Frenzel, 1892. Possibly there is a close relationship between this species and *Protomagalhaensia serpentula*.)
References: (1) Frenzel, 1892, 299; (2) Wasielewski, 1896, 138; (3) Labbé 1899, 35; (4) Ellis, 1913c, 265; (5) Watson, 1916a, 103.
Synonymy: Name unchanged.
Hosts: (a) *Panchlora exoleta* Burmeister, (1).
Habitat: Mid-intestine, (1a).
Distribution: Cordoba, Argentina, (1a).

Group 2. Gregarine thick.

Gregarina ohioensis Semans, 1939.
References: (1) This paper, parts II and III.
Hosts: (a) *Parcoblatta virginica* (Brunner), (1).
Habitat: Mid-intestine, (1a).
Distribution: Franklin County, Ohio, (1a).

Gregarina thomasi Semans, 1939.
References: (1) This paper, parts II and III.
Hosts: (a) *Parcoblatta pensylvanica* (DeGeer), (1).
Habitat: Enteric ceca and mid-intestine, (1a).
Distribution: Fairfield County, Ohio (1a).

Gregarina illinensis Watson, 1915.
References: (1) Watson, 1915, 34; (2) Watson, 1916a, 108; (3) Kamm, 1922a, 131; (4) Kamm, 1922b, 84; (5) this paper, part II.
Synonymy: Name unchanged.
Hosts: (a) *Parcoblatta pensylvanica* (DeGeer), (1).
Habitat: Alimentary canal, (1a).
Distribution: Urbana, Illinois, (1a).

Gregarina parcoblattae Semans, 1939.
References: (1) This paper, parts II and III.
Hosts: (a) *Parcoblatta uhleriana* (Saussure), (1); (b) *Parcoblatta pensylvanica* (DeGeer), (1).
Habitat: Mid-intestine, (1a), (1b).
Distribution: Fairfield County, Ohio, (1a), (1b); Franklin County, Ohio, (1b); Washington County, Ohio, (1a).

Gregarina blattarum Siebold, 1839. (*G. blattarum* described by Watson, 1916b, 73, appears to be a variation of that described in Europe, and is referred to elsewhere as "Watson variety" as contrasted with "Old World variety.")
References: (1) Siebold, 1837, 408; (2) Siebold, 1839, 67; (3) Dujardin, 1845, 638; (4) Frantzius, 1846; (5) Frantzius, 1848, 193, 195; (6) Stein, 1848, 223; (7) Diesing, 1851, 10; (8) Leidy, 1853a, 239; (9) Leidy, 1856, 47; (10) Diesing, 1859, 731; (11) Lankester, 1863, 85, 94; (12) Schneider, 1876, 92, etc.; (13) Bütschli, 1881, 385; (14) Schneider, 1882, 424, 442; (15) Balbiani, 1884, 13, 68, 170; (16) Kunstler, 1887, 32, 53; (17) Schneider, 1887, 74, 75; (18) Wolters, 1891, 102, 107, 115, 128, 131; (19) Léger, 1892, 45, 75, 93; (20) Marshall, 1893, 25; (21) Pfeiffer, 1893, 4, 132; (22) Schewiakoff, 1894, 342; (23) Wasielewski, 1896, 34, 136; (24) Schuster, 1898, 244; (25) Labbé, 1899, 35; (26) Magalhães, 1900, 38; (27) Caullery and Mesnil, 1901, 84; (28) Cuénot, 1901, 619; (29) Léger and Duboscq, 1901, 441; (30) Léger and Duboscq, 1902b, 421, 428; (31) Crawley, 1903a, 44; (32) Crawley, 1903b, 639; (33) Luhe, 1904, 118, 134, 139, 172; (34) Hall, 1907, 149, 151, etc.; (35) Léger and Duboscq, 1909, 88, 98; (36) Wellmer, 1910, 531; (37) Wellmer,

1911, 106, 113; (38) Ellis, 1913b, 83; (39) Ellis 1913c, 265; (40) Belar, 1916, 242; (41) Watson, 1916a, 99; (42) Watson, 1916b, 73; (43) Pinto, 1918b, 322; (44) Schiffman, 1919, 79; (45) Laveran and Franchini, 1920b, 332; (46) Kudo, 1922, 113; (47) Tejera, 1926, 1382; (48) Fantham, 1929, 389; (49) McAdow, 1931, 11; (50) this paper, part II.

Synonymy: *Gregarina* sp., (1); *Gregarina blattarum*, (2), (3), (4), (6), (13), (20), (24), (25), (28), (29), (31), (32), (33), (34), (35), (36), (37), (38), (39), (40), (41), (42), (43), (44), (45), (46), (47), (48), (49), (50); *Gregarina Blattarum*, (5), (7,) (9), (10), (11), (15); *Gregarina Blattae orientalis*, (8); *Clepsidrina Blattarum*, (12), (15), (17), (18); *Clepsidrina blattarum*, (14), (15), (16), (19), (21), (22), (23), (26), (27), (30); *Gregarina blattae orientalis*, (25).

Hosts: (a) *Parcoblatta pensylvanica* (DeGeer), (14); (b) *Blattella germanica* (Linnaeus), (31), (41); (c) *Blatta orientalis* Linnaeus, (2), (8), (12), (20), (22), (26), (28), (31), (36), (37), (42), (45), (49); (d) *Periplaneta americana* (Linnaeus), (24), (31), (34), (41), (49).

Habitat: Coelom, (26c); alimentary canal, (2c), (8c), (12c), (20c), (31b), (31c), (31d), (42c), (45c); enteric ceca, (26c), (49c), (49d); mid-intestine, (26c), (28c), (49c), (49d).

Distribution: Brazil, (26c); France, (12)c, (28c), (45c); East Prussia, (36c); Königsberg, Germany, (37c); Urbana, Illinois, (42c); Douglas Lake, Michigan, (38a); Raleigh, North Carolina, (31b), (31c), (31d); Ohio, (49c), (49d); Wyncote, Pennsylvania, (31b), (31c), (31d).

Subdivision 2. Hosts, Acrididae.

Gregarina rigida columna Semans, 1939.

References: (1) This paper, parts II and III.

Hosts: (a) *Arphia sulphurea* (Fabricius), (1); (b) *Chortophaga viridifasciata* (DeGeer), (1); (c) *Encoptolophus sordidus* (Burmeister), (1); (d) *Pardalophora apiculata* (Harris), (1); (e) *Dissosteira carolina* (Linnaeus), (1); (f) *Spharagemon bolli* Scudder, (1); (g) *S. collare collare* (Scudder), (1); (h) *Melanoplus obovatipennis* (Blatchley), (1); (i) *M. scudderi scudderi* (Uhler), (1); (j) *M. differentialis* (Thomas), (1); (k) *M. bivittatus* (Say), (1); (l) *M. mexicanus mexicanus* (Saussure), (1); (m) *M. keeleri luridus* (Dodge), (1).

Habitat: Base of enteric ceca, (1f), (1h), (1m); enteric ceca and mid-intestine, (1a), (1b), (1c), (1d), (1e), (1g), (1i), (1j), (1k), (1l), (1m).

Distribution: Gary, Indiana, (1g), (1j), (1k); Fairfield County, Ohio, (1a), (1b), (1d), (1i), (1k), (1l), (1m); Franklin County, Ohio, (1c), (1b); Licking County, Ohio, (1e), (1f), (1h), (1m); Union County, Ohio, (1j).

Gregarina rigida rigida (Hall, 1907) Ellis, 1913.

References: (1) Hall, 1907, 150, 169, etc.; (2) Crawley, 1907, 223; (3) Sokolow, 1911, 279; (4) Wellmer, 1911, 108; (5) Ellis, 1913a, 464; (6) Ellis, 1913b, 82; (7) Ellis, 1913c, 267; (8) Watson, 1915, 34; (9) Watson, 1916a, 105; (10) Kamm, 1920, 23; (11) this paper, parts II and III.

Synonymy: *Hirmocystis rigida* (1), (3), (4), (5); *Gregarina melanopli*, (2), (3), (6); *Gregarina rigida*, (7), (8), (9), (10); *Gregarina rigida rigida*, (11).

Hosts: (a) *Chorthippus curtipennis curtipennis* (Harris), (11); (b) *Arphia sulphurea* (Fabricius), (11); (c) *Encoptolophus sordidus* (Burmeister)?, (9); (d) *Dissosteira carolina* (Linnaeus), (11); (e) *Spharagemon bolli* Scudder, (11); (f) *Brachystola magna* (Girard), (5), (7); (g) *Schistocerca americana americana* (Drury)?, (9); (h) *Hesperotettix viridis praetensis* (Scudder)?, (9); (i) *Melanoplus obovatipennis* (Blatchley), (11); (j) *M. differentialis* (Thomas), (1), (9?), (11); (k) *M. bivittatus* (Say), (1), (2), (6), (9?), (11); (l) *M. femur-rubrum femur-rubrum* (DeGeer), (6), (9), (11); (m) *M. mexicanus mexicanus* (Saussure), (9?), (11); (n) *M. keeleri luridus* (Dodge), (6), (9?), (11); (o) *M. angustipennis* (Dodge), (1), (9?).

Habitat: Alimentary canal, (1j), (1k), (1o); gizzard, (11l); base of ceca, (11i), (11n); enteric ceca, (11a), (11c), (11d), (11j), (11k), (11l), (11m), (9?); mid-intestine, (11a), (11b), (11c), (11d), (11e), (11g), (11l), (11m), (11n).

Distribution: Canon City, Colorado, (1j), (1k), (1o); Colorado Springs, Colorado, (9?); Urbana, Illinois, (9?); Gary, Indiana, (11a), (11d), (11k), (11m); Douglas Lake, Michigan, (6k), (6l), (6n); Lincoln, Nebraska, (9?); Oyster Bay, New York, (9?); Fairfield County, Ohio, (11b), (11e), (11k), (11m), (11n); Franklin County, Ohio, (11c), (11d), (11j), (11l), (11n); Licking County, Ohio, (11i), (11n); Washington County, Ohio, (11j), (11l); Wyncote, Pennsylvania, (2k).

Gregarina indianensis Semans, 1939.

References: (1) This paper, parts II and III.

Hosts: (a) *Chorthippus curtipennis curtipennis* (Harris), (1); (b) *Melanoplus differentialis* (Thomas), (1); (c) *M. bivittatus* (Say), (1); (d) *M. mexicanus mexicanus* (Saussure), (1).

Habitat: Enteric ceca, (1a), (1b), (1c), (1d); mid-intestine, (1a), (1b), (1c), (1d).

Distribution: Gary, Indiana, (1a), (1b), (1c), (1d).

Gregarina nigra Watson, 1915.

References: (1) Watson, 1915, 33; (2) Watson, 1916a, 116; (3) Kamm, 1922a, 130; (4) Kamm, 1922b, 84; (5) Bush, 1928, 154, et. al.; (6) this paper, part II.

Synonymy: Name unchanged.

Hosts: (a) *Encoptolophus sordidus* (Burmeister), (1); (b) *Zonocerus elegans* (Thunberg), (5); (c) *Lentula* sp., (5); (d) *Cyrtacanthacris ruficornis* (Fabricius), (5); (e) *Melanoplus differentialis* (Thomas), (3), (4); (f) *M. femur-rubrum femur-rubrum* (DeGeer), (1), (6).

Habitat: Alimentary canal, (5b), (5c), (5d); mid-intestine, (6f).

Distribution: Pietermaritzburg, Natal, (5b), (5c), (5d); Urbana, Illinois, (1a), (1f), (3e), (4e); Washington County, Ohio, (6f).

Gregarina locustae Lankester, 1863.

References: (1) Leidy, 1853a, 239; (2) Leidy, 1856, 47; (3) Diesing, 1859, 730; (4) Lankester, 1863, 94; (5) Léger, 1897, 10; (6) Labbé, 1899, 35; (7) Crawley, 1903a, 54; (8) Crawley, 1903b, 640; (9) Crawley, 1907, 225; (10) Ellis, 1913c, 268; (11) Watson, 1916a, 100; (12) this paper, parts II and III.

Synonymy: *Gregarina Locustae Carolinae*, (1); *Gregarina Locustae carolinae*, (2); *Gregarina fimbriata*, (3); *Gregarina Locustae*, (4), (5); *Gregarina locustaecarolinae*, (6); *Stephanophora locustae-carolinae*, (7), (8); *Gregarina locustae-carolinae*, (9), (10); *Gregarina locustae*, (11), (12).

Hosts: (a) *Dissosteira carolina* (Linnaeus), (1), (9), (12).

Habitat: Alimentary canal, (1a); mid-intestine, (12a).

Distribution: Gary, Indiana, (12a); Wyncote, Pennsylvania, (9a).

Gregarina paranensis (Künckel d'Herculais, 1899) Watson, 1916.

References: (1) Künckel d'Herculais, 1899, 622; (2) Watson, 1916, 104.

Synonymy: *Clepsidrina paranensis*, (1); *Gregarina paranensis*, (2).

Hosts: (a) *Schistocerca paranensis* (Burmeister), (1).

Habitat: Alimentary canal, (1a).

Distribution: Parana, Argentina, (1a).

Gregarina acridiorum Léger, 1893.

References: (1) Léger, 1893, 811; (2) Wasielewski, 1896, 138, 139; (3) Léger, 1897, 27; (4) Labbé, 1899, 10; (5) Léger and Duboscq, 1901, 440, 441; (6) Léger and Duboscq, 1902b, 381, 423, 424, 430, 462; (7) Lühe, 1904, 91, 96, 134; (8) Léger and Duboscq, 1909, 88; (9) Wellmer, 1910, 531; (10) Wellmer, 1911, 112; (11) Watson, 1916a, 104.

Synonymy: *Clepsidrina acridiorum*, (1), (2), (5), (6); *Clepsidrina Acridiorum*, (3); *Gregarina acridiorum*, (4), (5), (6), (7), (8), (9), (10), (11).

Hosts: (a) *Tryxalis* sp., (1), (3); (b) *Oedipoda coerulescens* Linnaeus, (9), (10); (c) *Sphingonotus* sp., (3); (d) *Pamphagus* sp., (1), (3); (e) *Calliptamus italicus* (Linnaeus), (5), (6).

Habitat: Alimentary canal, (1a), (1d) (3a), (3c), (3d), (6e); mid-intestine, (10b).

Distribution: Nemours, Algeria, (1a), (1d); France, (3a), (3c), (3d), (6e); Germany, (9b), (10b).

Subdivision 3. Host, one of the Copiphorinae, subfamily of the Tettigoniidae.

Gregarina chagasi Pinto, 1918. (It is singular that this is the only protozoan parasite of any kind described for Tettigoniidae.)

References: (1) Pinto, 1918a, 49; (2) Pinto, 1919, 81; (3) Kamm, 1922a, 132; (4) Kamm, 1922b, 84.

Synonymy: Name unchanged.

Hosts: (a) *Neoconocephalus fratellus* (Griffini), (1).

Habitat: Alimentary canal, (1a).

Distribution: Manguinhos, Brazil, (1a).

Subdivision 4. Hosts, Gryllidae.

Gregarina kingi Crawley, 1907.

References: (1) Crawley, 1907, 221; (2) Sokolow, 1911, 279; (3) Ellis, 1913c, 271; (4) Watson, 1916a, 106; (5) this paper, parts II and III.

Synonymy: *Gregarina kingi*, (1), (2), (4), (5); *Gigaductus kingi*, (3).

Hosts: (a) *Gryllus assimilis* Fabricius, (1), (5).

Habitat: Alimentary canal, (1a); gizzard, (5a); enteric ceca, (5a); mid-intestine, (5a).

Distribution: Beach Haven, New Jersey, (1a); Franklin and Washington Counties, Ohio, (5a); Wyncote, Pennsylvania, (1a).

Gregarina galliveri Watson, 1915.

References: (1) Watson, 1915, 33; (2) Watson, 1916a, 111; (3) Kamm, 1922a, 130; (4) Kamm, 1922b, 84; (5) this paper, parts II and III.

Synonymy: Name unchanged.

Hosts: (a) *Gryllus assimilis* Fabricius, (1), (2), (5); (b) *Hapithus agitator agitator* Uhler, (5).

Habitat: Alimentary canal, (1a), (2a); crop and gizzard, (5a), (5b); enteric ceca, (5a), (5b); mid-intestine, (5a), (5b).

Distribution: Oyster Bay, New York, (1a), (2a); Franklin County, Ohio, (5a); Washington County, Ohio, (5a), (5b).

Division 3. Complex of structural similarities. Hosts, Raphidophorinae, subfamily of the Gryllacrididae.

Gregarina hadenoeci Semans, 1939.

References: (1) This paper, parts II and III.

Hosts: (a) *Hadenoecus puteanus* Scudder, (1).

Habitat: Mid-intestine, (1a).

Distribution: Washington County, Ohio, (1a).

Gregarina longiducta Ellis, 1913.
References: (1) Ellis, 1913b, 78; (2) Ellis, 1913c, 266; (3) Watson, 1916a, 107; (4) Kamm, 1922a, 129; (5) Kamm, 1922b, 83; (6) this paper, part II.
Synonymy: Name unchanged.
Hosts: (a) *Ceuthophilus pallidipes* E. M. Walker, (erroneously, according to T. H. Hubbell, called *C. maculatus* (Harris)), (1); (b) *Ceuthophilus meridionalis* Scudder, (erroneously, according to Hubbell, called *C. latens* Scudder), (1).
Habitat: Alimentary canal, (1a), (1b).
Distribution: Douglas Lake, Michigan, (1a), (1b).

Gregarina proteocephala Semans, 1939.
References: (1) This paper, parts II and III.
Hosts: (a) *Ceuthophilus gracilipes* (Haldeman), (1).
Habitat: Mid-intestine, (1a).
Distribution: Washington County, Ohio, (1a).

Gregarina stygia Watson, 1915.
References: (1) Watson, 1915, 33; (2) Watson, 1916a, 114; (3) Kamm, 1922a, 131; (4) Kamm, 1922b, 83; (5) this paper, part II.
Synonymy: Name unchanged.
Hosts: (a) Probably *Ceuthophilus gracilipes* (Haldeman), erroneously called *C. stygia* (Scudder), according to T. H. Hubbell. (1), (4).
Habitat: Alimentary canal, (1a).
Distribution: Cold Spring Harbor, New York, (1a).

Gregarina consobrina Ellis, 1913.
References: (1) Ellis, 1913c, 267; (2) Watson, 1916a, 108; (3) Kamm, 1922a, 128; (4) Kamm, 1922b, 83; (5) this paper, part II.
Synonymy: Name unchanged.
Hosts: (a) *Ceuthophilus uniformis* Scudder, (1).
Habitat: ?
Distribution: Near Boulder, Colorado, (1a).

Gregarina sp.
References: (1) This paper, parts II and III.
Hosts: (a) *Ceuthophilus divergens* Scudder, (1).
Habitat: Mid-intestine, (1a).
Distribution: Franklin County, Ohio, (1a).

Gregarina neglecta Watson, 1916.
References: (1) Watson, 1916b, 69; (2) Kamm, 1922a, 131; (3) Kamm, 1922b, 83; (4) this paper, part II.
Synonymy: Name unchanged.
Hosts: (a) Uncertain. *Ceuthophilus nigricans* Scudder, or, possibly, *Ceuthophilus brevipes* Scudder, or? (According to T. H. Hubbell.), (1).
Habitat: ? (1a).
Distribution: Oyster Bay, New York, (1a).

Gregarina ceuthophili Semans, 1939.
References: (1) This paper, parts II and III.
Hosts: (a) *Ceuthophilus gracilipes* (Haldeman), (1); (b) *Ceuthophilus brevipes* Scudder, (1); (c) *Ceuthophilus divergens* Scudder, (1).
Habitat: Mid-intestine, (1a), (1b), (1c).
Distribution: Fairfield and Washington Counties, Ohio, (1a); Franklin County, Ohio, (1c); Licking County, Ohio, (1b).

Gregarina prima Semans, 1939.
References: (1) This paper, parts II and III.
Hosts: (a) *Ceuthophilus uhleri* Scudder, (1).
Habitat: Mid-intestine, (1a).
Distribution: Fairfield and Logan Counties, Ohio, (1a).

Gregarina udeopsyllae Watson, 1916.
References: (1) Watson, 1916a, 117; (2) Kamm, 1922a, 131; (3) Kamm, 1922b, 84; (4) this paper, part II.
Synonymy: Name unchanged.
Hosts: (a) *Udeopsylla robusta* (Haldeman), (1).
Habitat: Mid-intestine, (1a).
Distribution: Urbana, Illinois, (1a).

Division 4. *Leidyana*-like cephalont. Hosts, Gryllidae.

Gregarina macrocephala (Schneider, 1875) Labbé, 1899.
References: (1) Schneider, 1876, 18, 19, 32, 86; (2) Schneider, 1882, 442; (3) Schneider, 1885,

25; (4) Kunstler, 1887, 47; (5) Schneider, 1887, 73; (6) Léger, 1892, 67; (7) Léger, 1893, 811; (8) Wasielewski, 1896, 34, 137; (9) Cuénot, 1897, 54; (10) Léger, 1897, 10; (11) Labbé, 1899, 10; (12) Cuénot, 1901, 595; (13) Lühe, 1904, 139, 149; (14) Watson, 1916a, 102.

Synonymy: *Clepsidrina macrocephala*, (1), (2), (3), (4), (5), (6), (7), (8), (10); *Clepsidrina gryllorum*, (9); *Gregarina macrocephala*, (11), (12), (13), (14).

Hosts: (a) *Acheta campestris* (Linnaeus), (1); (b) *Gryllus domesticus* Linnaeus, (9), (11); (c) *Nemobius sylvestris* (Bosc d'Antic), (2), (11).

Habitat: Alimentary canal, (2c), (9b), (11b), (11c).

Distribution: France, (1a), (2c); Ardennes, France, (9b).

Division 5. Protomerite of satellite almost obliterated. Hosts, Acrydiinae, subfamily of Acrididae.

Gregarina acrydiinarum Semans, 1939.

References: (1) This paper, parts II and III.

Hosts: (a) *Acrydium arenosum angustum* Hancock, (1); (b) *Paratettix cucullatus cucullatus* (Burmeister), (1).

Habitat: Mid-intestine, (1a), (1b).

Distribution: Franklin County, Ohio, (1a); Delaware County, Ohio, (1b).

Division 6. Relationships not apparent.

Gregarina oviceps Diesing, 1859.

References: (1) Leidy, 1853a, 238; (2) Leidy, 1856, 47; (3) Diesing, 1859, 728; (4) Lankester, 1863, 94; (5) Labbé 1899, 35; (6) Crawley, 1903a, 45; (7) Crawley, 1903b, 639; (8) Crawley, 1907, 220; (9) Ellis, 1913c, 266; (10) Watson, 1915, 34; (11) Watson, 1916a, 101; (12) Bhatia and Setna, 1924, 287; (13) this paper, parts II and III.

Synonymy: *Gregarina Achetae abbreviatae*, (1), (2); *Gregarina oviceps*, (3), (11), (12), (13); *Gregarina Achetae*, (4); *Gregarina achetaeabbreviatae*, (5), (6), (7); *Gregarina achetae-abbreviatae*, (8), (9), (10).

Hosts: (a) *Gryllus assimilis* Fabricius, (1), (8), (9), (11), (13); (b) *Gryllus* spp., (12).

Habitat: Alimentary canal, (11a); gizzard, (1a), (12b), (13a); mid-intestine, (12b), (13a).

Distribution: Lahore, India, (12b); Urbana, Illinois, (11a); Douglas Lake, Michigan, (9a); Beach Haven, New Jersey, (8a); Oyster Bay, New York, (11a); Franklin and Washington Counties, Ohio, (13a); Haverford and Philadelphia, Pennsylvania, (11a); Wyncote, Pennsylvania, (8a).

Gregarina davini Léger and Duboscq, 1899.

References: (1) Léger and Duboscq, 1899, 38; (2) Léger and Duboscq, 1902b, 380, 461; (3) Mercier, 1908a, 377; (4) Sokolow, 1911, 278; (5) Watson, 1916a, 126.

Synonymy: *Gregarina Davini*, (1), (2), (5); *Clepsidrina davini*, (3); *Gregarina davini*, (4).

Hosts: (a) *Gryllomorpha dalmatina* (Ocskay de Ocskō), (1).

Habitat: Mid-intestine, (1a).

Distribution: France ?, (1a).

Gregarina ovata Dufour, 1828.

References: (1) Dufour, 1828, 367; (2) Dufour, 1837, 12; (3) Siebold, 1837, 408; (4) Hammerschmidt, 1838; (5) Desmarest, 1845, 317; (6) Frantzius, 1846; (7) Frantzius, 1848, 194, 195; (8) Diesing, 1851, 10; (9) Leidy, 1853a, 233; (10) Diesing, 1859, 731; (11) Lankester, 1863, 94; (12) Schneider, 1873, 515; (13) Schneider, 1876, 90; (14) Schneider, 1882, 442; (15) Balbiani, 1884, 13; (16) Schneider, 1885, 25; (17) Wasielewski, 1896, 22, 33, 137; (18) Labbé, 1899, 10; (19) Paehler, 1904, 64; (20) Schnitzler, 1905, 309; (21) Léger and Duboscq, 1909, 85; (22) Brindley and Potts, 1910, 836; (23) Wellmer, 1910, 531; (24) Wellmer, 1911, 106, 111; (25) Ellis, 1913c, 265; (26) Watson, 1916a, 97; (27) Brindley, 1918, 167; (28) Schiffman, 1919, 84; (29) this paper, part II.

Synonymy: *Gregarina ovata*, (1), (2), (3), (5), (6), (7), (8), (9), (10), (11), (12), (15), (18), (19), (21), (22), (23), (24), (25), (26), (28), (29); *Clepsidrina conoidea*, (4); *Clepsidrina ovata*, (13), (14), (16), (17), (20), (27).

Hosts: (a) *Acheta campestris* (Linnaeus), (2); (b) *Forficula auricularia* Linnaeus. (This insect belongs to the family Forficulidae of the Dermaptera, formerly, but no longer, included in the Orthoptera.) (1), (12), (13), (19), (20), (23), (24), (27); (c) *Forficula* sp., (22).

Habitat: Alimentary canal, (1b), (19b), (20b), (22c), (24b), (27b); mid-intestine, (12b).

Distribution: France, (1b), (13b); East Prussia, (23b); Marburg, Germany, (20b); St. Marys, Isles of Scilly, (27b); Farne Islands, (22c).

Gregarina legeri Pinto, 1918.

References: (1) Pinto, 1918a, 113; (2) Pinto, 1918b, 322; (3) Pinto, 1919, 86; (4) Kamm, 1922a, 140.

Synonymy: Name unchanged.

Hosts: (a) *Periplaneta americana* (Linnaeus), (1).

Habitat: Alimentary canal, (1a).

Distribution: Rio de Janeiro, Brazil, (1a).

Gregarina sphaerulosa Dufour, 1837. (Only cyst is known.)
References: (1) Dufour, 1837, 12; (2) Frantzius, 1846; (3) Diesing, 1851, 11; (4) Diesing, 1859, 732; (5) Lankester, 1863, 94; (6) Léger, 1892, 112; (7) Labbé, 1899, 13; (8) Watson, 1916a, 126.
Synonymy: *Gregarina sphaerulosa*, (1), (3), (4), (5), (8); *Eirmocystis gryllotalpae*, (6); *Hirmocystis gryllotalpae*, (7).
Hosts: (a) *Gryllotalpa* spp., (1); (b) *Oedipoda* spp., (1).
Habitat: Mid-intestine, (1a), (1b).
Distribution: France: (1a), (1b).

Genus 4. **Protomagalhaensia** Pinto, 1918. Spores barrel-shaped with spine at each corner. Sporonts attenuated, several individuals in association, often attached laterally.

Protomagalhaensia serpentula (Magalhães, 1900) Pinto, 1918.
References: (1) Magalhães, 1900, 43; (2) Sokolow, 1911, 278; (3) Ellis, 1913c, 266; (4) Watson, 1916a, 104; (5) Pinto, 1918b, 321; (6) Kamm, 1922a, 133.
Synonymy: *Gregarina serpentula*, (1), (2), (3), (4); *Protomagalhaensia serpentula*, (5), (6).
Hosts: (a) *Periplaneta americana* (Linnaeus), (1).
Habitat: Coelom and alimentary canal, (1a).
Distribution: Rio de Janeiro, Brazil, (1a).

Genus 5. **Gamocystis** Schneider, 1875. Associative. Protomerite only in young stages. Sporulation partial, with spore ducts. Spores cylindric.

Gamocystis tenax Schneider, 1875.
References: (1) Schneider, 1876, 99, etc.; (2) Schneider, 1882, 444, 445; (3) Balbiani, 1884, 13, 50; (4) Wasielewski, 1896, 36, 136; (5) Labbé, 1899, 12; (6) Lühe, 1904, 155; (7) Wellmer, 1910, 532; (8) Wellmer, 1911, 108, 122; (9) Ellis, 1913c, 271; (10) Watson, 1916a, 122.
Synonymy: Name unchanged.
Hosts: (a) *Ectobia lapponica* (Linnaeus), (1), (7), (8).
Habitat: Alimentary canal, (1a), (8a).
Distribution: France, (1a); East Prussia, (7a); Germany, (8a).

Genus 6. **Tettigonospora** Smith, 1930. Associative. Dehiscence by spore ducts. Spores spherical.

Tettigonospora stenopelmati (Smith, 1929) Smith, 1930.
References: (1) Smith, 1929, 57; (2) Smith, 1930, 445.
Synonymy: *Coccospora stenopelmati*, (1); *Tettigonospora stenopelmati*, (2).
Hosts: (a) *Stenopelmatus pictus* Scudder, (1); (b) *Stenopelmatus fuscus* Haldeman, (1); (c) *Stenopelmatus intermedius* Davis and Smith, (2).
Habitat: Ceca and mid-intestine, (1a), (1b); excrement, (2c).
Distribution: Central California, (1a), (1b); Oakland, California, (2c).

Genus 7. **Hirmocystis** Labbé, 1899. Associations of from 2 to 12 or more. Epimerite a small, cylindric papilla. Cysts dehisce by simple rupture. Spores ovoid.

Hirmocystis gryllotalpae (Léger, 1892) Labbé, 1899.
References: (1) Léger, 1892, 112; (2) Wasielewski, 1896, 35; (3) Léger, 1897, 11; (4) Labbé, 1899, 13; (5) Watson, 1916a, 123.
Synonymy: *Gregarina sphaerulosa*, (1), (4); *Eirmocystis gryllotalpae*, (1), (2); *Eirmocystis Gryllotalpae*, (3); *Hirmocystis gryllotalpae*, (4), (5).
Hosts: (a) "Courtilieres" (a gryllid), (1).
Habitat: Alimentary canal, (1a).
Distribution: Vallee du Clain, Poitou, France, (1a).

Family 2. *Actinocephalidae* Léger, 1892.

Sporonts solitary. Epimerite varied. Cysts dehisce by simple rupture. Spores irregular, biconic, or cylindro-biconic.

Genus 1. **Pileocephalus** Schneider, 1875. Epimerite a lance-shaped or simple cone. Spores ovoid, pointed.

Pileocephalus tachycines Semans, 1939.
References: (1) This paper, parts II and III.
Hosts: (a) *Tachycines asinamorus* (Adelung), (1).
Habitat: Mid-intestine, (1a).
Distribution: Franklin County, Ohio, (1a).

Pileocephalus blaberae (Frenzel, 1892) Labbé, 1899.
References: (1) Frenzel, 1892, 300; (2) Wasielewski, 1896, 136; (3) Labbé, 1899, 20; (4) Ellis, 1913c, 266; (5) Watson, 1916a, 123; (6) This paper, part II.

Synonymy: *Gregarina blaberae*, (1), (2), (4); *Pileocephalus blaberae*, (3), (5), (6).
Hosts: (a) *Blaptica dubia* (Serville), and related species, (1).
Habitat: Mid-intestine, (1a).
Distribution: Cordoba, Argentina, (1a).

Genus 2. **Actinocephalus** Stein, 1848. Epimerite small, sessile or on a short neck, with 8 or 10 short, sharp spines or simple, bifurcate digitiform processes. Spores biconic.

Division 1. South African species.

Actinocephalus giganteus Bush, 1928.
References: (1) Bush, 1928, 149, et. al.
Synonymy: Name unchanged.
Hosts: (a) "Majority of the grasshopper species." (This refers to 35 ? species of "Acridiidae" examined by Bush.) " . . . did not occur in *Locustana pardalina*," (1).
Habitat: Alimentary canal, (1a).
Distribution: Pietermaritzburg, Natal, (1a).

Actinocephalus sp. Bush, 1928.
References: (1) Bush, 1928, 152, et. al.
Hosts: (a) *Parga xanthoptera* (Stal), (1); (b) *Catantops humeralis* (Thunberg), (1).
Habitat: Alimentary canal, (1a), (1b).
Distribution: Pietermaritzburg, Natal, (1a), (1b).

Actinocephalus amphoriformis Bush, 1928.
References: (1) Bush, 1928, 149, et. al.
Synonymy: Name unchanged.
Hosts: (a) "Practically all the species of grasshoppers." (This refers to 35 ? species of "Acridiidae" examined by Bush.) . . . "did not occur in *Locustana pardalina*." (1).
Habitat: Alimentary canal, (1a).
Distribution: Pietermaritzburg, Natal, (1a).

Division 2. North American species.

Actinocephalus sp.
References: (1) This paper, parts II and III.
Hosts: (a) *Pardalophora apiculata* (Harris), (1).
Habitat: Mid-intestine, (1a).
Distribution: Washington County, Ohio, (1a).

Actinocephalus fimbriatus (Diesing, 1859) Watson, 1916.
References: (1) Leidy, 1853a, 239; (2) Leidy, 1856, 47; (3) Diesing, 1859, 730; (4) Crawley, 1903a, 54; (5) Crawley, 1903b, 640; (6) Crawley, 1907, 226; (7) Ellis, 1913c, 278; (8) Watson, 1916a, 124; (9) this paper, part II.
Synonymy: *Gregarina Locustae Carolinae*, (1); *Gregarina Locustae carolinae*, (2); *Gregarina fimbriata*, (3); *Stephanophora locustaecarolinae*, (4), (5); *Stephanophora pachyderma*, (6); *Actinocephalus pachydermus*, (7); *Actinocephalus fimbriatus*, (8), (9).
Hosts: (a) *Dissosteira carolina* (Linnaeus), (1), (6).
Habitat: Alimentary canal, (1a).
Distribution: Wyncote, Pennsylvania, (6a).

Actinocephalus elongatus Semans, 1939.
References: (1) This paper, parts II and III.
Hosts: (a) *Dichromorpha viridis* (Scudder), (1); (b) *Arphia sulphurea* (Fabricius), (1); (c) *Chortophaga viridifasciata* (DeGeer), (1); (d) *Schistocerca americana americana* (Drury), (1, *A. elongatus* ?); (e) *Melanoplus mexicanus mexicanus* (Saussure), (1, *A. elongatus* ?).
Habitat: Coelom, (1c); enteric ceca, (1c), (1b); mid-intestine, (1a), (1c), (1d).
Distribution: Fairfield County, Ohio, (1c); Franklin County, Ohio, (1d); Washington County, Ohio, (1a), (1b), (1c).

Genus 3. **Legeria** Labbé, 1899. Epimerite not known. Protomerite dilated and massive. Septum convex upward. Spores cylindro-conic.

Legeria sp. Bush, 1928. (Possibly the immature of the South African *Gregarina nigra* Watson. See this paper, part II, under *Gregarina indianensis* n. sp.)
References: (1) Bush, 1928, 153, et. al.
Hosts: (a) *Phloeonotus jugatus* (F. Walker), (1).
Habitat: Alimentary canal, (1a).
Distribution: Pietermaritzburg, Natal, (1a).

Subclass 2. Neosporidia Schaudinn, 1900.

Spores formed more or less continuously throughout the trophic stages, the sporoblasts being carried about with the organism, which may ultimately become a huge mass of spores.

Order 1. Microsporidia Balbiani, 1884.

Small spores, frequently less than 5 microns in length. Possess one, or exceptionally, two polar capsules, which under pressure extrude exceedingly long filaments.

Family 1. *Nosematidae* Labbé, 1899.

Ovoid or pyriform spores developed from uninucleate rounded bodies which are the products of multiple or binary fission of the vegetative forms.

Genus 1. **Plistophora** Gurley, 1893. Each sporont gives rise to many spores, more than 16.

Plistophora periplanetae (Lutz and Splendore, 1903) Perrin, 1905.

References: (1) Schaudinn, 1902, 309; (2) Lutz and Splendore, 1903, 154; (3) Perrin, 1905, 204; (4) Mercier, 1906a, 1083; (5) Perrin, 1906, 615; (6) Mercier, 1908a, 373; (7) Mercier, 1908c, 41; (8) Shiwago, 1909, 647; (9) Wellmer, 1910, 532; (10) Epstein, 1911, 677; (11) Shiwago, 1911, 49; (12) Wellmer, 1911, 145; (13) Swarczewsky, 1914, 50, 74, 91; (14) Georgévitch, 1925a, 1191; (15) Georgévitch, 1925b, 102, 104; (16) Georgévitch, 1927, 9.

Synonymy: Not named, (1); *Nosema periplanetae*, (2); *Pleistophora periplanetae*, (3), (5), (8), (9), (10), (11), (12), (13), (14), (15); *Plistophora periplanetae*, (4), (7,) (16), (17).

Hosts: (a) *Blattella germanica* (Linnaeus), (12); (b) *Blatta orientalis* Linnaeus, (3), (4), (8), (9), (10), (12), (14); (c) *Periplaneta americana* (Linnaeus), (2); (d) "Blattes," (15).

Habitat: Alimentary canal, (2c); Malpighian tubules, (3b), (4b), (8b), (10b), (12a), (12b), (15d).

Distribution: Brazil, (2c); England, (3b); France, (4b); Konigsberg, Germany, (12b); Munich, Germany, (10b); East Prussia, (9b); Moscow, Russia, (8a), (8b), (10b); Belgrade, Yugoslavia, (14b).

Species related to *Plistophora periplanetae* (Lutz and Splendore, 1903) mentioned by Lutz and Splendore, 1903.

References: (1) Lutz and Splendore, 1903, 154.
Hosts: (a) *Gryllotalpa* sp., (1).
Habitat: Mid-intestine, wall, (1a).
Distribution: Brazil, (1a).

Species related to *Plistophora periplanetae* (Lutz and Splendore, 1903) mentioned by Perrin, 1905.

References: (1) Perrin, 1905, 208.
Hosts: (a) *Blatta orientalis* Linnaeus, (1).
Habitat: Malpighian tubules, (1a).
Distribution: England, (1a).

Plistophora sp. Mercier.

References: (1) Mercier, 1908, 373; (2) Kudo, 1924, 178.
Hosts: (a) *Blatta orientalis* Linnaeus, (1).
Habitat: Fat bodies, (1a).
Distribution: ?

Order 2. Haplosporidia Lühe, 1900.

Spores spherical or ovoid, the surface variously marked with ridges, but without polar capsules. Possess a tail-like process in some cases.

Genus 1. **Coelosporidium** Mesnil and Marchoux, 1897. Body small, forming cysts. Spore without a filament.

Coelosporidium periplanetae (Lutz and Splendore, 1903) Swarczewsky, 1914.

References: (1) Lutz and Splendore, 1903, 154; (2) Crawley, 1905, 158; (3) Caullery and Mesnil, 1905, 108, 160; (4) Doflein, 1909, 816; (5) Wellmer, 1911, 146; (6) Swarczewsky, 1914, 91, 101, 104; (7) Kudo, 1922, 113; (8) Kudo, 1924, 188; (9) Georgévitch, 1927, 9; (10) Kudo, 1931, 332.

Synonymy: *Nosema periplanetae*, (1); *Coelosporidium blattellae*, (2), (3); *Bertramia blatellae*, (4), (5); *Coelosporidium periplanetae*, (6), (7), (8), (9), (10).

Hosts: (a) *Blattella germanica* (Linnaeus), (2), (5); (b) *Blatta orientalis* Linnaeus, (7).

Habitat: Malpighian tubules, (2a), (5a).

Distribution: Königsberg, Germany, (5a); United States, (2a); Urbana, Illinois, (7b).